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THE HANDLING OF DANGEROUS GOODS

A HANDBOOK

FOR THE USE OF GOVERNMENT AND RAILWAY OFFICIALS
CARRIERS, SHIPOWNERS, INSURANCE COMPANIES
MANUFACTURERS AND USERS OF SUCH GOODS, AND OTHERS

COMPRISING

NOTES ON THE PROPERTIES OF INFLAMMATORY, EXPLOSIVE, AND OTHER DANGEROUS COMPOUNDS, AND THE MODES OF STORAGE AND TRANSPORT THEREOF, WITH OFFICIAL CLASSIFICATIONS, PARLIAMENTARY ENACTMENTS, PARTICULARS OF RECORDED ACCIDENTS, ETC.

BY

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FORMERLY OF THE GREAT WESTERN AND GREAT EASTERN RAILWAYS
AUTHOR OF "ENGINEERING CHEMISTRY," ETC.

Capio Lumen

LONDON
CROSBY LOCKWOOD AND SON
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1896

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PREFACE.

It having fallen to the lot of the writer, as a Chemical Expert, to attend several meetings of Railway Goods Managers at the Railway Clearing-House, in London, to assist in the re-classification of explosives and other dangerous goods carried by Railway Companies, it occurred to him that a work of reference, giving in a popular form particulars as to the nature and character of such materials, and information bearing on the questions of their storage and transport, would be found of value by goods managers, railway agents, carriers, and indeed all persons interested in the use, storage, and transport of dangerous goods.

It would be needless to comment upon the numerous accidents, many of them fatal in effect, and often resulting in the destruction of valuable property, which are recorded as occurring through ignorance of the dangerous nature of materials handled; and while we cannot all be chemists, it is most desirable that every one responsible for the handling of dangerous goods should be sufficiently acquainted with their characteristics under the conditions met with in daily experience to enable them to avoid unnecessary risks; and it is with the object of rendering assistance in this direction that the present volume has been compiled. Should the work be found to answer its purpose, those who use it will be enabled not only to guard against injuries to life and property, but to protect the interests of the firms or companies represented by them, to whose custody dangerous goods are proposed to be committed. In preparing the volume, the writer has received much valuable assistance from officials of the Government and of various Railway Companies, many of whom have expressed the opinion that the production of such a work would meet a long-felt want.

It has been the writer's aim to produce a book for the purpose in such a form that a reader without knowledge of chemistry may be able to gain from its pages the requisite information; and he trusts the work may meet with the approbation of those actively interested in the subject. Any suggestions for its improvement will be gladly considered by him when a new edition shall be in preparation.

PALACE CHAMBERS,
WESTMINSTER, LONDON, S.W.,
October 1895.

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THE HANDLING OF DANGEROUS GOODS.

SECTION I.

ACIDS.

ACETIC ACID.

Synonyms.—*Methane Carboxylic Acid*, *Methylformic Acid*, *Pyroligneous Acid*, *White Wine Vinegar*, *Glacial Acetic Acid*, *Acidum Aceticum*, $C_2H_4O_2$.

Source.—Pure acetic acid is prepared by distilling five parts by weight of fused sodium acetate with six parts by weight of concentrated sulphuric acid, bisulphate of soda being left in the retort. It is also obtained in the destructive distillation of wood, sawdust, or spent dye woods. The distillate, containing besides this acid, tarry matters, methyl alcohol, acetone, &c., is neutralised with carbonate of soda, the alcohol, &c., is distilled off, the solution evaporated, and the residue heated to expel tarry substances, and the resultant crude sodic acetate is distilled with sulphuric acid, when crude acetic acid is produced. This variety is known as *pyroligneous acid*. Acetic acid is also prepared by the oxidation of alcohol. The fermentation of alcoholic liquids, such as wine, beer, &c., in contact with air produces the various vinegars of commerce. Vinegar contains on an average about 5 per cent. of acetic acid. $\frac{1}{1000}$ of sulphuric acid is allowed in malt vinegar by law, with the questionable object of preventing putrefaction.

Characters.—Pure acetic acid is, at temperatures below 60° F., a glass-like crystalline solid. Above this temperature it is a colourless mobile liquid. This concentrated acid is known as *glacial acetic acid.* It has a pleasant, pungent odour, and is a powerful corrosive, raising blisters upon the skin. The concentrated acid is an acrid poison. It boils at 244° F., giving off inflammable vapours. Its molecular weight is 60, and sp. gr. 1.063. It is one of the most stable of the organic acids. Liquids containing acetic acid have a corrosive action upon many metals, especially those containing copper, with which the metal forms the well-known green *verdigris*, consisting of various basic acetates of the metal.

Acetic acid is soluble in all proportions in water, alcohol, and ether, and dissolves fibrin, albumen, essential oils, &c.

Uses.—Acetic acid is largely used in the preparation of the acetates of copper, aluminium, iron, lead, and sodium; in calico printing, in the preparation of varnishes and colouring matters; as a solvent for hydrocarbons in certain industries; in photography, as vinegar for domestic use, a constituent of smelling salts, &c.

In medicine it is used as a liniment for rheumatism, a local irritant to allay fevers, and as a solvent for corns and warts. It is given internally as a refrigerant, under the name of *acidum acetum dilutum*, containing about 12 per cent. of the acid, and given in doses up to one fluid ounce.

ARSENIOUS ANHYDRIDE.

Synonyms.—*White Arsenic, Arsenious Acid, Arsenious Sesquioxide, Arsenic Trioxide, Acidum Arseniosum*, As_2O_3.

Source.—This compound is produced by roasting arsenical ores, such as mispickel, which is an arsenical sulphide of iron. It is also obtained in the roasting of certain ores of copper and nickel as a by-product in the metallurgical treatment of these minerals. The arsenious oxide condenses in chambers or flues leading from the furnace, and is periodically raked out and purified by resublimation.

Characters.—Arsenious anhydride exists in two forms, a vitreous and a crystalline variety. When freshly obtained, it has the appearance of a semi-transparent, lamellated, vitreous mass. On exposure to the atmosphere it becomes yellow in colour, and gradually becomes opaque. By grinding the transparent variety to powder it becomes opaque. The opaque form has a specific gravity of 3.699, while the transparent variety is slightly heavier, being 3.7385 times as heavy as water. Cold water dissolves only about 2 per cent. of the oxide; boiling water dissolves about 12 per cent., but it is freely soluble in hydrochloric acid. Nitric acid and aqua-regia dissolve the acid and convert it into arsenic acid. When heated to 380° F. it sublimes and condenses into transparent octohedra crystals upon warm surfaces. Its vapour is colourless and odourless. Arsenious anhydride, or *white arsenic* of the shops, is frequently used as a poison, so small a quantity as two grains being attended with fatal results. Taken in excessive doses, it causes faintness, sickness, nausea, and intense thirst.

Uses.—For the manufacture of metallic arsenic, ingredient in vermin poisons, for the production of salts called arsenites. It is much used in medicine, and given in doses of $\frac{1}{60}$ to $\frac{1}{12}$ of a grain as a gastric stimulant. Combined with potash it is a constituent of an important drug known as Liquor Arsenicalis or Fowler's Solution.

CHROMIC ANHYDRIDE.

Synonyms.—*Chromic Acid*, *Chromium Trioxide*, CrO_3.

Source.—This compound is prepared by acting upon chromates with sulphuric acid. The usual process consists in mixing 4 volumes of a cold saturated solution of potassic bichromate with 5 volumes of sulphuric acid. On cooling, chromic anhydride separates out in the form of bright crimson needles. It may also be prepared by decomposing fluoride of chromium with water.

Characters.—Chromic anhydride is a crimson substance, crystallising in needles. It has a specific gravity of 2.676. On exposure to the air, it absorbs water and becomes deliquescent. It has a sour, metallic taste, and is corrosive in its action. On heating to 392° F., it fuses; further heating decomposes it, with the evolution of oxygen and the formation of chromic oxide. During the decomposition it becomes incandescent. On heating with hydrochloric acid, chlorine gas is given off, and chromic chloride produced. It is poisonous.

Uses.—Principally as an oxidising agent.

HYDROCYANIC ACID.

Synonyms.—*Prussic Acid, Cyanide of Hydrogen, Acidum Hydrocyanicum Dilutum, HCN.*

Source.—Hydrocyanic acid occurs in nature in laurel and cherry leaves, in bitter almonds and amygdalin. It may be prepared by distilling metallic cyanides with hydrochloric acid, or by heating ammonium formate. It is usually prepared commercially by distilling a mixture of potassium ferrocyanide with dilute sulphuric acid. The concentrated acid is obtained by the action of sulphuretted hydrogen upon mercuric cyanide.

Characters.—The pure acid is a colourless, thin, and volatile liquid, having a density of 0.7058 at 45° F., boiling at 79° F., and congealing at 0° F. It is very inflammable, and burns with a violet flame. It has a powerful and characteristic odour, resembling that of bitter almond oil or peach blossoms. It is soluble in water and alcohol in all proportions, and exhibits a slight acid reaction. The strong acid cannot be preserved, since it decomposes into formate of ammonium and an indefinite brown substance. It is a most violent poison, very small quantities of the strong acid producing instantaneous death, and even when largely diluted it has a powerful effect upon the animal system.

Uses.—The concentrated acid being so unstable, its applications are limited. The *acidum hydrocyanicum dilutum*, which contains 2 per cent. of the acid, is used in medicine as an anæsthetic and sedative in doses from 2 to 8 minims.

HYDROFLUORIC ACID.

Synonyms.—*Fluoric Acid, Hydric Fluoride, HF.*

Source.—The concentrated acid is prepared by heating potassium hydrogen fluoride in a platinum retort. But the strong aqueous solution of commerce is prepared by heating a mixture of 1 part of prepared and finely powdered fluor spar (calcium fluoride) with 2 or 3 parts of sulphuric acid in a leaden retort connected with a leaden condensing arrangement.

Characters.—Hydrofluoric acid is a colourless, volatile, and fuming liquid, its vapours being highly corrosive and poisonous. Its molecular weight is 20, and the strong aqueous solution has a specific gravity of 1.06. Its percentage composition is hydrogen, 5; fluorine, 95. It has a great affinity for water, with which it combines, with the development of great heat and a hissing noise. The anhydrous acid boils at 67° F., and the commercial acid at 248° F. The dilute acid is very dangerous to handle. It has a most corrosive action upon the skin, producing an intense burning sensation. It dissolves most metals with the formation of their fluorides, with the exception of platinum, lead, gold, and mercury. It has a very corrosive action upon glass and on all silicates, and in consequence it cannot be kept in glass bottles. It is usually preserved in vessels made of guttapercha, upon which it has practically no action. The acid has such remarkable corrosive properties that there are few materials that it will not attack. It is not inflammable or explosive.

Uses.—The dilute acid is much used for glass etching, which is performed by first coating the glass with wax, and then tracing the design upon it with a sharp-pointed tool, and then exposing to the action off the vapour or allowing the acid to stand upon the markings for some time, which soon act upon the parts uncovered by the wax. When the etching is performed by the vapour of the acid, the design is white and opaque.

Hydrofluoric acid is also a constituent of certain inks used for making permanent writing or marks upon glass, and is much used in the laboratory for the decomposition of silicates and for the preparation of fluorides.

HYDROCHLORIC ACID.

Synonyms.—*Muriatic Acid*, *Spirit of Salts*, *Chloride of Hydrogen*, *Chlorhydric Acid*, *Acidum Hydrochloricum*, *HCl*.

Source.—This acid is prepared upon the commercial scale by the action of sulphuric acid upon sodium chloride or common salt. The acid distils off, leaving a residuum of sulphate of soda. It is obtained synthetically by mixing equal volumes of hydrogen and chlorine gases, and exposing to direct sunlight, or by the application of an electric spark to the mixture. The gases combine with explosive violence with the formation of hydrochloric acid gas. It occurs in nature to some extent as a constituent of volcanic emanations.

Characters.—Hydrochloric acid is a colourless gas of a pungent odour and very acid taste. If breathed, although largely diluted with air, it produces irritation of the air passages, causing coughing. It also irritates the eyes, and has a smarting action upon the skin. It is very injurious to vegetation, and has a corrosive action upon metals, walls, pictures, &c. Its molecular weight is 36.5, and density 18.25. Under a pressure of 40 atmospheres at 50° F. it condenses to a colourless liquid of sp. gr. 1.27. Its percentage composition is hydrogen, 2.74; chlorine, 97.26. It is not inflammable, neither will it support combustion. It fumes when in contact with the air, owing to its combination with atmospheric moisture. It is extremely soluble in water, 1 volume of which at 40° F. would absorb about 480 volumes of the gas, the liquid being increased in volume about one-third and acquiring a density of 1.2109. This is a colourless and fuming liquid, and contains 43 per cent. of the acid. The ordinary commercial hydrochloric or muriatic acid of the shops has generally a yellowish colour, due to the presence of small quantities of chloride of iron, chlorine, or organic matter. It generally has a sp. gr. of 1.16, and contains about 32 per cent. of the acid.

The following table gives the amount of hydrochloric acid contained in aqueous solutions of various specific gravities at 60° F. :—

Specific Gravity	HCl per cent.	Specific Gravity.	HCl per cent.	Specific Gravity.	HCl per cent.	Specific Gravity.	HCl per cent
1.200	40.777	1.1515	30.582	1.1000	20.388	1.0497	10.194
1.1982	40.369	1.1494	30.174	1.0980	19.980	1.0477	9.786
1.1964	39.961	1.1473	29.767	1.0960	19.572	1.0457	9.379
1.1946	39.554	1.1452	29.359	1.0939	19.165	1.0437	8.971
1.1928	39.146	1.1431	28.951	1.0919	18.757	1.0417	8.563
1.1910	38.738	1.141	28.544	1.0899	18.349	1.0397	8.155
1.1893	38.330	1.1389	28.136	1.0879	17.941	1.0377	7.747
1.1875	37.923	1.1369	27.728	1.0859	17.534	1.0357	7.340
1.1857	37.516	1.1349	27.321	1.0838	17.126	1.0337	6.932
1.1846	37.108	1.1328	26.913	1.0818	16.718	1.0318	6.524
1.1822	36.700	1.1308	26.505	1.0798	16.310	1.0298	6.116
1.1802	36.292	1.1287	26.098	1.0778	15.902	1.0279	5.709
1.1782	35.884	1.1267	25.690	1.0758	15.494	1.0259	5.301
1.1762	35.476	1.1247	25.282	1.0738	15.087	1.0239	4.893
1.1741	35.068	1.1226	24.874	1.0718	14.679	1.0220	4.486
1.1721	34.660	1.1206	24.466	1.0697	14.271	1.0200	4.078
1.1701	34.252	1.1185	24.058	1.0677	13.863	1.0180	3.670
1.1681	33.845	1.1164	23.650	1.0657	13.456	1.0160	3.262
1.1661	33.437	1.1143	23.242	1.0637	13.049	1.0140	2.854
1.1641	33.029	1.1123	22.834	1.0617	12.641	1.0120	2.447
1.1620	32.621	1.1102	22.426	1.0597	12.233	1.0100	2.039
1.1599	32.213	1.1082	22.019	1.0577	11.825	1.0080	1.631
1.1578	31.805	1.1061	21.611	1.0557	11.418	1.0060	1.124
1.1557	31.398	1.1041	21.203	1.0537	11.010	1.0040	.816
1.1536	30.990	1.1020	20.796	1.0517	10.602	1.0020	.408

The aqueous solution of hydrochloric acid reddens litmus strongly. It dissolves many metals with the liberation of hydrogen gas and the formation of chlorides of the metals. It neutralises alkalies with the production of their chlorides. The strong acid is a powerful corrosive poison.

Uses.—Hydrochloric acid is extensively used in the arts and manufactures for bleaching powder or chloride of lime, potassic chlorate, and sal ammoniac. It is used as a solvent for tin by the dyer and calico printer, and by tin and copper smiths for soldering purposes. It is indispensable in the chemical laboratory and for the manufacture of fine chemicals. It is used in medicine under the name of *acidum hydrochloricum dilutum*, which is an aqueous solution of the acid, showing a specific gravity of 1.052, and containing a little over 10½ per cent. of the pure gas. This is given in certain diseases, such as dyspepsia, in from 20 to 30 minim doses.

OXALIC ACID.

Synonyms.—$H_2C_2O_4 2Aq$.

Source.—Prepared by heating sawdust with a mixture of caustic soda and caustic potash to a temperature of 460° to 480° F. The mixture is then boiled with water, filtered, and the solution evaporated. Sodium oxalate separates out in granules. These are now boiled with milk of lime, and thus become converted into oxalate of lime. The lime salt is then decomposed with dilute sulphuric acid. Sulphate of lime and oxalic acid being formed, these are separated by filtration, and the solution of oxalic acid concentrated and crystallised.

Characters.—Oxalic acid crystallises in large white monoclinic crystals containing two molecules of water, which it loses on heating to 212° F., the weight being reduced 28.5 per cent. It is very soluble in water and alcohol, and has an extreme acid taste. Taken in large doses, it acts as a powerful corrosive poison. Sulphuric acid decomposes it completely, with the evolution of carbonic oxide and carbonic dioxide gases.

Uses.—The acid is used in calico printing and dyeing, for bleaching flax, straw, and leather, for cleaning brass, &c.

NITRIC ACID.

Synonyms.—*Aqua Fortis*, *Hydric Nitrate*, *Acidium Nitricum*, HNO_3.

Source.—Nitric acid is prepared on the commercial scale by heating a mixture of sodium nitrate or Chili saltpetre with sulphuric acid in iron retorts connected with earthenware condensers and receivers. Nitric acid is distilled over and condensed, while the residuum in the retorts consists of sulphate of soda.

Characters.—Pure nitric acid is a colourless, fuming, limpid liquid, the vapours from which, if breathed, are very irritating to the air passages, and very corrosive to most substances. It has a specific gravity of 1.53 at 60° F., and a molecular weight of 63. It begins to boil at 184° F., but owing to the decomposition of the liquid with the formation of nitrous and oxygen gases, the temperature gradually rises until 250° F. is reached, when the temperature of the residual acid remains constant, and the liquid distils unchanged. Its percentage composition is hydrogen, 1.59; nitrogen, 22.22; oxygen, 76.19. It freezes at about -40° F. The commercial acid has a yellowish red colour, due to the presence of the lower oxides of nitrogen. These oxides are also produced in the pure colourless acid if it be exposed to sunlight for some time. It is soluble in all proportions in water.

Nitric acid is a powerful oxidising agent. It contains over three-quarters of its weight of oxygen, and parts with a fraction of it with great ease.

The diluted acid dissolves most metals with the formation of nitrates or oxides with the liberations of nitrous fumes. It has no action upon gold or platinum. It has a very marked action upon the skin and all albuminous substances, producing a yellow stain very difficult to remove. It has a most destructive action on all animal and vegetable textile goods. It converts sulphur and phosphorus into sulphuric and phosphoric acids, and if dropped on to hot powdered charcoal oxidation takes place so rapidly that the charcoal burns vividly. Nitric acid is a powerful irritant poison.

Uses.—The applications of nitric acid in the arts are very important. It is extensively used for the manufacture of such explosives as nitro-glycerine, dynamite, picric acid, nitro-cellulose (gun cotton), roburite, cordite, &c. It is in constant request for the products of nitro-benzol, aniline dyes, aqua-regia, nitrous ether, &c., and for cleaning brass and copper goods. It is indispensable in the chemical laboratory and for the manufacture of fine chemicals. In medicine a dilute aqueous solution, containing 10 per cent. of the acid, and known as *acidum nitricum dilutum*, is used for certain diseases in 10 to 30 minim doses. The strong acid is often used as a caustic to destroy warts and corns, and also in metal engraving.

NITRO-HYDROCHLORIC ACID.

Synonyms.—*Aqua-Regia, Nitro-Muriatic Acid, Acidum Nitro-Hydrochloricum.*

Source.—This acid is generally prepared by adding 1 part of nitric to 3 parts of hydrochloric acid. At first the mixture turns yellow, and eventually a bright sparkling red, due to a reaction which takes place between the two acids with the formation of free chlorine and oxychlorides of nitrogen. This mixed acid derives the name of aqua-regia from the fact that it dissolves the noble metals gold and platinum, and the other rare platinoid metals, the single acids being without action upon them.

Characters.—Nitro-hydrochloric acid, or aqua-regia, is a red, sparkling, mobile liquid, giving off, when exposed, very irritating and corrosive fumes. It is a powerful oxidising agent. It dissolves the metals with the formation of their perchlorides. It has a most destructive action upon all metallic and organic substances, and is an irritant poison. It is not inflammable or explosive. It is soluble in water in all proportions.

Uses.—As a solvent for gold and platinum. The chlorides of gold and platinum are largely used in photography, and as chemical reagents in the laboratory. As an oxidising agent. In medicine it is used under the name of *acidum nitro-hydrochloricum dilutum*, and contains nitric acid 3, hydrochloric acid 4, and water 25 parts, and is administered in 5 to 20 minim doses.

SULPHURIC ACID.

Synonyms.—*Oil of Vitriol*, *Hydrogen Sulphate*, *Acidum Sulphuricum*, *Protohydrate of Sulphuric Acid*, H_2SO_4.

Source.—This, the most important of all the acids, is prepared on the commercial scale from sulphur, iron pyrites, or disulphide of iron. By roasting these substances in a current of air sulphur dioxide gas is produced. This is conveyed into large leaden chambers, and there mixed with nitrous vapours (produced by the action of sulphuric acid upon nitre) and steam. These vapours react upon each other, forming dilute sulphuric acid, which condenses upon the floor of the chambers, after which the liquid is drawn off and concentrated by boiling. The acid is also formed by the gradual oxidation of sulphurous acid in water, and also by the action of water upon sulphur trioxide.

An acid of higher concentration is prepared at Nordhausen, in Saxony, by heating dehydrated ferrous sulphate (green vitriol) in earthen retorts. A brown fuming acid distils over, and is known in commerce as Nordhausen oil of vitriol. A residuum of oxide of iron is left in the retorts, which is used as a red pigment, and known under the name of *colcothar*.

Characters.—The sulphuric acid, or oil of vitriol, of commerce, is a colourless, odourless, and dense oily-looking liquid, of specific gravity 1.842. It boils at 640° F., and freezes at about $-29°$ F. Its molecular weight is 98, and its percentage composition is sulphur, 32.65; oxygen, 65.31; hydrogen, 2.04. It is very hygroscopic, and on exposure rapidly absorbs moisture from the atmosphere. Great heat is developed on mixing the concentrated acid with water. On adding 4 parts of the strong acid to 1 part of water the temperature rises from 32° F. to 212° F. Great care should be exercised in mixing sulphuric acid with water. The acid should always be added gradually to the water, and not *vice versa.* A sudden mixture should be avoided, since they are apt to combine with explosive violence. Accidents frequently result from this cause.

The following table shows the percentage of sulphuric acid in aqueous solutions of various specific gravities:—

Specific Gravity.	Per cent.	Specific Gravity.	Per cent.	Specific Gravity.	Per cent.	Specific Gravity.	Per cent.
1.8426	100	1.675	75	1.398	50	1.182	25
1.842	99	1.663	74	1.3886	49	1.174	24
1.8406	98	1.651	73	1.379	48	1.167	23
1.840	97	1.639	72	1.370	47	1.159	22
1.8384	96	1.627	71	1.361	46	1.1516	21
1.8376	95	1.615	70	1.351	45	1.144	20
1.8356	94	1.604	69	1.342	44	1.136	19
1.834	93	1.592	68	1.333	43	1.129	18
1.831	92	1.580	67	1.324	42	1.121	17
1.827	91	1.568	66	1.315	41	1.1136	16
1.822	90	1.557	65	1.306	40	1.106	15
1.816	89	1.545	64	1.2976	39	1.098	14
1.809	88	1.534	63	1.289	38	1.091	13
1.802	87	1.523	62	1.281	37	1.083	12
1.794	86	1.512	61	1.272	36	1.0756	11
1.786	85	1.501	60	1.264	35	1.068	10
1.777	84	1.490	59	1.256	34	1.061	9
1.767	83	1.480	58	1.2476	33	1.0536	8
1.756	82	1.469	57	1.239	32	1.0464	7
1.745	81	1.4586	56	1.231	31	1.039	6
1.734	80	1.448	55	1.223	30	1.032	5
1.722	79	1.438	54	1.215	29	1.0256	4
1.710	78	1.428	53	1.2066	28	1.019	3
1.698	77	1.418	52	1.198	27	1.013	2
1.686	76	1.408	51	1.190	26	1.0064	1

The commercial acid is often of a yellow or dark brown colour. This is principally due to its charring action on pieces of organic matter, such as straw, &c., that may have fallen into it. It has a very destructive action upon wood, linen, and cloth of all kinds. The dilute cold acid dissolves such metals as iron, nickel, cobalt, zinc, and manganese, forming sulphates of the metals and the liberation of hydrogen gas. The cold concentrated acid has very little action upon metals. When the acid is boiled, however, in contact with such metals as silver, copper, mercury, antimony, lead, tin, and bismuth, sulphurous anhydride gas is disengaged, and sulphates of the metals formed. Gold and platinum are not acted upon even by the concentrated boiling acid. Sulphuric acid is a violent poison, and has a most caustic action upon the skin, causing an intense burning sensation, and is frequently used by evil-disposed persons for facial disfiguration, and known as *vitriol throwing*.

Uses.—Sulphuric acid is the most extensively employed of all the acids. It is used in very large quantities in the production of carbonate of soda from common salt, and for converting the ammoniacal liquor of the gasworks into sulphate of ammonia, now so largely used as a manure. It is used in the production of nitro-glycerine and other explosives, and the more volatile acids, such as hydrochloric, hydrofluoric, and nitric, &c. Its applications in the chemical laboratory and chemical works are very numerous. In the manufacture of tin plates it is extensively used to dissolve off the oxide of iron from the surface of the iron plates prior to the tinning process. In medicine it is used as a refrigerant, under the name of *acidum sulphuricum dilutum;* sp. gr., 1.094, and containing about 10 per cent. of the acid, and administered in 5 to 30 minim doses. *Nordhausen oil of vitriol* is principally used as a solvent for indigo for dyeing purposes. The applications of sulphuric acid in the arts and manufactures are so numerous that the prosperity of a civilised country can be said to be very nearly in direct ratio to its consumption.

SECTION II.

ALKALIES.

AMMONIUM HYDRATE.

Synonyms.—*Ammonia*, *Spirit of Hartshorn*, *Sal Volatile*, *Liquor Ammoniæ Fortior*, NH_4HO, $AmHO$.

Source.—This alkaline liquid is an aqueous solution or combination of ammonia gas, and it is produced commercially by heating sulphate or chloride of ammonium with quicklime, and condensing or absorbing the resulting gas in water.

Characters.—Ammonium hydrate is a colourless alkaline liquid, and gives off the characteristic and pungent odour of ammonia gas (*see* Ammonia Gas, page 28). The strong solution of the gas has a specific gravity of 0.880. It neutralises acids, and is strongly alkaline. Excessive inhalation of its vapour is poisonous, but breathed in small quantities it acts as a stimulant to the pulse and respiration. The amount of ammonia gas absorbed by water depends upon the temperature of the latter. The higher the temperature, the less gas is absorbed, and *vice versa*. One part of water at 32° F. absorbs 1,149 times its volume of the gas, while at 68° F. only 681 volumes are absorbed. By heating ammonium hydrate to 212° F., all the ammonia gas escapes, and water remains. The following table shows the percentage of ammonia (NH_3) in aqueous solutions of the gas of various specific gravities :—

Temp. 60° F.

Specific Gravity.	Ammonia Gas per cent.	Specific Gravity.	Ammonia Gas per cent.	Specific Gravity.	Ammonia Gas per cent.
0.8844	36	0.9133	24	0.9520	12
0.8864	35	0.9162	23	0.9556	11
0.8885	34	0.9191	22	0.9593	10
0.8907	33	0.9221	21	0.9631	9
0.8929	32	0.9251	20	0.9670	8
0.8953	31	0.9283	19	0.9709	7
0.8976	30	0.9314	18	0.9749	6
0.9001	29	0.9347	17	0.9790	5
0.9026	28	0.9380	16	0.9031	4
0.9052	27	0.9414	15	0.9873	3
0.9078	26	0.9449	14	0.9915	2
0.9106	25	0.9484	13	0.9959	1

Uses.—The applications of ammonium hydrate are important. It is indispensable in the chemical laboratory, and in medicine it is largely used as a liniment in combination with other substances. Small doses of the dilute solution are given internally as a gastric stimulant. It is a constituent of smelling salts and of manure.

LIME.

Synonyms.—*Quicklime, Caustic Lime, Calcic Oxide, CaO.*

Source.—Pure lime is obtained by calcining marble, or by adding a solution of carbonate of ammonia to a solution of chloride of calcium, and calcining the resulting precipitate of carbonate of lime. The lime of commerce is obtained by roasting limestone (an impure carbonate of lime) in kilns, whereby carbonic acid gas is evolved, and caustic lime produced.

Characters.—When pure, lime is a white, amorphous, and infusible body. It has a specific gravity of 3.18, and consists of 71.43 per cent. of calcium, and 28.57 per cent. of oxygen. On exposure to the air it gradually absorbs moisture and carbonic acid, and crumbles to powder. It is then usually termed *air-slaked.* When water is gradually added to a lump of lime, it swells considerably, and gives out great heat, being at the same time converted into hydrate of lime. Lime is soluble to the extent of 1 part in 700 of cold water, and on heating the solution to the boiling point about 50 per cent. is precipitated, being less soluble in hot than in cold water. The solution has an alkaline reaction and a caustic taste. Lime is soluble in dilute acids, with the formation of its salts.

Uses.—The applications of lime are very extensive. Enormous quantities of lime in the form of limestone are consumed in the smelting of iron and other ores. It is the principal ingredient of mortar and cements, and is used in large quantities for purifying coal gas, for the manufacture of bleaching powder and the *softening of hard* water, for the removal of hair from hides, &c., prior to the tanning process. Agriculture absorbs a considerable quantity of lime for the disintegration of soil, and destroying worms, &c. When heated with the oxyhydrogen flame, it gives out a most intense light, known as *limelight*, now much used in lecture demonstration, photography, &c. *Milk of lime* is a saturated solution of hydrate of lime, and containing the finely divided hydrate in suspension. This is best prepared by *slaking* lime with twice its weight of boiling water, and then diluting with cold water. It is used as a whitewash for cattle waggons, sheds, and outhouses, &c., and is disinfectant in character. In medicine *liquor calcis* (lime water) is used to mix with milk to prevent its curdling in the stomach, for acidity, and for destroying intestinal threadworms, the dose being from 1 to 4 fluid ounces.

POTASSIUM HYDRATE.

Synonyms.—*Caustic Potash, Potash, Potassa Caustica, Potassa Fusa, KHO.*

Source.—This substance is obtained from carbonate of potash, or *pearl ash* solution, contained in an iron pot, by mixing it with slaked lime in small quantities at a time, the whole being kept at the boiling point. Insoluble carbonate of lime is formed, and potassium hydrate remains in solution. When all the carbonate has been precipitated, the whole is boiled for about a quarter of an hour, and the insoluble matter allowed to settle. The clear caustic liquor is drawn off into silver basins, and evaporated until the solid hydrate produced begins to volatilise. The viscid liquid is then run into moulds and allowed to solidify. Caustic potash prepared in this manner is rarely pure, but may be easily purified by digestion in alcohol. Most of the impurities remain insoluble, and the potash can be obtained from the solution by evaporation and fusion.

Characters.—Potassium hydrate is a brittle greyish-white substance, with a molecular weight of 56.1, and a specific gravity of 2.2. It is exceedingly deliquescent, and rapidly absorbs water and carbonic acid from the atmosphere. It is a powerful alkali, and neutralises acids forming the potash salts. It is soluble in about half its weight of water, and gives out much heat during solution. Alcohol also freely dissolves it. It has a very acrid taste, is a strong cautery, and has a destructive action upon vegetable and animal matters. The strong solution is very poisonous.

Uses.—Caustic potash has extensive applications, large quantities being consumed for glass and soap making, and for fine chemicals. An aqueous solution is used as an anti-incrustating fluid in steam boilers, and sometimes mixed with various organic substances, and then known as *boiler composition*. It is also known as *painters' solution*, being used for dissolving off old paint from wood work, walls, &c. It is indispensable in the chemical laboratory as a reagent. The aqueous solution, *liquor potassæ*, of the British Pharmacopœia, has a specific gravity of 1.058, and contains nearly 6 per cent. of the hydrate, and is used to cleanse the skin before operations, and as a solvent for a morbid epidermis in certain diseases of the skin. A dilute solution is sometimes given internally as a gastric sedative for dyspepsia.

SODIUM AMALGAM.

Synonyms.—(*Alloy of Mercury*,) Na_3Hg.

Sources, Characters.—Sodium amalgam is obtained by the direct union of metallic mercury with the metal sodium, by heating up a solution of the element in mercury to 824° F. They unite with very considerable evolution of heat.

Sodium amalgam containing excess of mercury, when heated to 824° F., leaves the fixed compound Na_3Hg. The alloy of sodium with 30 parts of mercury is hard and crystalline; that of 60 parts of mercury becomes pasty when slightly warmed. Like sodium this alloy must be kept in naphtha to preserve it.

Uses.—Sodium amalgam is chiefly used in lecture demonstrations. It is also used for the formation of amalgams of other metals, viz., barium, calcium, &c.

SODIUM HYDRATE.

Synonyms.—*Caustic Soda*, *Soda Caustica*, *Soda*, $NaHO$.

Source.—On a large scale this substance is obtained from "black ash," or "soda ash," or carbonate of soda solution of specific gravity 1.1, by mixing with burnt lime, which combines with the carbonic acid of the soda, producing insoluble carbonate of lime and caustic soda, which is soluble in the liquid. It is allowed to stand, the clear liquid transferred to shallow pans and evaporated, after which the concentrated liquor is heated in iron pots until it becomes viscid and purified by forcing air through it. It is then cast into sticks or run into iron drums, and there solidified. When required chemically pure, special processes are resorted to for the purpose.

Characters.—Caustic soda is a brittle greyish-white substance, with a molecular weight of 40, and specific gravity of 2.13. It is very deliquescent, and rapidly absorbs moisture and carbonic acid from the atmosphere. It is a powerful alkaline caustic, and neutralises the acids forming the salts of soda. It is soluble in about half its weight of water, and during solution gives out great heat. Alcohol also dissolves it freely. It has a very acrid taste, and is a strong cautery, and has a destructive action upon vegetable and animal matters.

Uses.—The applications of caustic soda are practically the same as those of caustic potash (*vide* page 17). The *liquor sodæ* of the British Pharmacopœia has a specific gravity of 1.047, and contains 4.1 per cent. of soda.

SODIUM PEROXIDE.

Synonyms.—*Sodium dioxide*, Na_2O_2.

Source, Characters, &c.—Pure sodium peroxide is obtained by heating sodium in a flask of hard glass filled with nitrogen till the sodium is melted, then sending a slow stream of dry air and heating till the metal is changed to a yellowish white solid, and heating this for some time in dry oxygen. It is a white solid, becoming yellowish on heating.

It deliquesces gradually in air, and then is gradually changed into sodium carbonate. It is soluble in water, with production of much heat; on further heating, oxygen being evolved.

Sodium peroxide acts as an energetic oxidising agent when heated. Carbon, iodine, sulphur, phosphorus, and tin are oxidised more or less rapidly.

When in contact with wood and such like bodies, spontaneous combustion or explosion, if confined, is likely to ensue.

SECTION III.

SALTS.

CALCIUM CHLORIDE.

Synonyms.—*Chloride of Calcium*, $CaCl_2$.

Source.—This salt is obtained by dissolving chalk in hydrochloric acid; carbon dioxide gas is evolved, and on evaporating the solution to dryness, and fusing the residue, calcium chloride is produced as a white mass. Large quantities of the salt are now obtained as a secondary product in the manufacture of carbonate of ammonia.

Characters.—Calcium chloride occurs in commerce as a white anhydrous porous salt, and it can also be obtained crystallised in six-sided striated prisms. The fused salt has a specific gravity of 2.485, and molecular weight of 111. The crystallised salt has a specific gravity of 1.680. Its percentage composition is calcium, 36.03; chlorine, 63.97. Anhydrous calcium chloride is very deliquescent, and is extremely soluble in water, and also in alcohol. A concentrated aqueous solution of the salt boils at 355° F.

Uses.—As a desiccating agent, and is used as a flux in certain metallurgical operations. When mixed with snow, it constitutes a powerful freezing agent.

CHLORATE OF POTASSIUM.

Synonyms. — *Chlorate of Potash*, *Potassii Chloras*, $KClO_3$.

Source.—This salt may be prepared by passing chlorine gas through a solution of caustic potash, or more economically by the following process:—Chlorine gas is transmitted through milk of lime until saturated with it. Calcium chlorate and calcium chloride are thus formed. Potassium chloride is next added to the solution of mixed salts, whereby the calcium chlorate is converted into potassium chlorate, which is easily separated from the solution by evaporation and crystallisation.

Characters.—White and crystallising in small anhydrous rhomboidal tablets. Its molecular weight is 122.6, and specific gravity 2.326. It is inodorous, and possesses a cooling taste. Boiling water dissolves 61.5 parts of the salt. It melts at about 800° F., and at a higher temperature evolves 39.21 per cent. of oxygen gas, leaving a residue of potassic chloride. If combustible substances, such as phosphorus, sulphur, sugar, and charcoal be rubbed with the chlorate, oxidation takes place so rapidly as to cause detonation and explosion.

Uses.—The applications of chlorate of potash are important, and it is in constant demand for making oxygen gas, lucifer matches, calico printing, and as an oxidising agent, and is a constituent of various fireworks and explosives of the "chlorate mixture class." It is used in medicine either in solution or in the form of lozenges for inflammation of the throat, stomach, &c.

CHLORIDE OF IRON.

Synonyms.—*Muriate of Iron*, *Perchloride of Iron*, *Sesquichloride of Iron*, *Ferric Chloride*, *Ferri Perchloridi*, Fe_2Cl_6.

Source.—This salt is prepared as an anhydrous sublimate in brown scales by passing a current of chlorine gas over iron filings heated to redness; also in a hydrated condition by evaporating a solution of ferrous chloride which has been saturated with chlorine gas, and by dissolving peroxide of iron (ferric oxide) in hydrochloric acid and evaporating the solution.

Characters.—The anhydrous chloride of iron, which has a molecular weight of 325, is very deliquescent, and combines with water with a hissing noise and considerable rise of temperature, with which it forms a red solution which has an acid reaction, and on evaporation yields large deliquescent crystals containing variable amounts of water. It is also soluble in alcohol and ether. On boiling an aqueous solution of ferric chloride it is decomposed, soluble colloidal ferric oxide and free hydrochloric acid being formed. A strong solution deodorises organic solutions, such as sewage, and is reduced to some extent to ferrous chloride. It has a destructive action upon vegetable and animal textures. An aqueous solution of the salt is known as *iron liquor*.

Uses.—As a disinfectant, a chemical reagent, and is a constituent of various drugs and inks.

CHLORIDE OF LIME.

Synonyms.—*Bleaching Powder*, *Calcium Hypochlorite*, *Calx Chlorinata*, *Chlorinated Lime*, $Ca_3H_6O_6Cl_4$.

Source.—Chloride of lime is prepared by passing chlorine gas over slaked lime. The chlorine is generated by the action of hydrochloric acid upon manganese dioxide contained in stone "stills." The slaked lime is contained in "chambers" or "condensers" connected with the stills. The absorption of the chlorine must take place at as low a temperature as possible to prevent the formation of chlorate of lime.

Characters.—When pure, bleaching powder is a white powder, giving off a characteristic odour of hypochlorous acid. On exposure to the atmosphere, moisture and carbonic acid are absorbed, chlorine and hypochlorous acid being given off.

It contains from 30 to 39 per cent. of available chlorine, and is a powerful bleaching agent and disinfectant. It is partially soluble in water, leaving a large residue of hydrate of lime. Acids decompose it with the liberation of chlorine gas.

Chloride of soda and *chloride of potash* are compounds possessing similar properties.

Uses.—This important substance is extensively used for bleaching. The materials required to be bleached are soaked in a solution of bleaching powder in water, and then transferred to a dilute solution of sulphuric or hydrochloric acid; chlorine gas is generated, which decolourises the materials. It is also much used for disinfecting urinals, drains, &c.

MERCURIC CHLORIDE.

Synonyms.—*Dichloride, Bichloride or Perchloride of Mercury, Corrosive Sublimate, Hydrargyri Perchloridum,* $HgCl_2$.

Source.—This salt may be prepared by the action of chlorine gas upon heated mercury. It is manufactured commercially by mixing 2½ parts of sulphate of mercury with 1 part of sodium chloride or *common salt*, and carefully heating in glass vessels. Mercuric chloride sublimes, and sodium sulphate remains as a residuum.

Characters.—Mercuric chloride or *corrosive sublimate* is a white salt crystallising in needles or the rhombic form. Its molecular weight is 271, and specific gravity 5.42. It fuses at 509° F., and boils at 563° F., giving off intense acrid and poisonous fumes. It is soluble in water, alcohol, and ether. An aqueous solution of mercuric chloride, on standing for some time, decomposes and deposits a white precipitate of *calomel.* It combines with albuminous tissues, and is a powerful acrid poison, and is one of the most effectual antiseptics and bactericides known.

Uses.—As an antiseptic and disinfectant for the preservation of anatomical specimens, and for the prevention of decay of wood, cordage, canvas, &c. It is used in medicine internally and externally, and is a reagent of the analyst.

NITRATE OF POTASSIUM.

Synonyms.—*Nitrate of Potash*, *Nitre*, *Saltpetre*, *Potassic Nitrate*, *Potassii Nitras*, KNO_3.

Source.—Potassic nitrate occurs in nature in large quantities, and is a constituent in certain soils of India, Arabia, Persia, and Spain, and in more or less quantities in many other soils. To extract the nitre from these soils, they are lixiviated with water, and allowed to clarify, and the aqueous solution of nitre and other matters is concentrated by evaporation. The residue is treated with a minimum quantity of hot water, so as to dissolve the whole of the nitre from the foreign matters. The concentrated solution is diluted, and boiled with glue to separate organic matter, and the nitrate of potash is then obtained from the solution by evaporation and crystallisation. It is also obtained from sodium nitrate or Chili saltpetre, by acting upon a solution of the latter with a hot concentrated solution of pearl ash (carbonate of potash). Carbonate of soda is precipitated, and nitre remains in solution, from which it is obtained by evaporation and crystallisation. Saltpetre is formed on the Continent from the decomposition of animal matters. Aggregation of animal matters, ashes, and lime are exposed to the action of air, and watered at intervals with stable runnings, and the nitrate formed extracted with water, and obtained from the solution by evaporation and crystallisation. Magnesic and calcic nitrates are also dissolved out, but these can be converted into potassic nitrate by treatment with a solution of *pearl ash.*

Characters.—Pure potassic nitrate is a white salt crystallising in rhombic prisms. It is soluble in 3½ times its weight of cold water, but it is insoluble in alcohol. It has a molecular weight of 101.1, and its specific gravity is 2.070. It fuses without decomposition when heated to 642° F., but at a red heat it decomposes, giving off oxygen, and leaving a residuum of potassium nitrate, which by further heating may be converted into the oxides of potassium. Nitre is a powerful oxidising agent.

Uses.—Mixed with charcoal and sulphur, it constitutes gunpowder, and is also a constituent of other nitro-explosives and fireworks. In the laboratory it is used as an oxidisation and fluxing agent, and is used in the "curing" of bacon. It is sometimes used in medicine as a refrigerant in certain febrile diseases.

STANNIC CHLORIDE.

Synonyms.—*Tetrachloride of Tin*, *Muriate of Tin*, *Fuming Liquor of Libavius*, *formerly Bichloride of Tin*, *Tin Liquor*, $SnCl_4$.

Source.—This liquid is obtained by heating metallic tin with chloride of mercury (corrosive sublimate), and condensing the fumes produced, or by passing a current of dry chlorine over melted tin, and condensing the resulting chloride.

Characters.—A colourless, caustic, and densely fuming liquid. Its molecular weight is 260.1, and specific gravity 2.279, and boils at 238° F. When mixed with water, great heat is generated, owing to the production of a hydrate of the salt. It absorbs water from the air, and deposits crystals of the hydrated chloride. When mixed with one-third its weight with water, it forms a mass known as *butyrum stanni*, or *butter of tin*. A combination of the chloride with ammonium chloride is used by dyers, and called *pink salt*. *Nitro-muriate of tin*, prepared by dissolving tin in cold nitro-muriatic acid (*aqua-regia*), or by adding hydrochloric acid, nitrate of sodium, and sulphuric acid to a solution of tin crystals, is much used by dyers.

Uses.—Principally in dyeing and calico printings, in combination with other substances.

SULPHUR CHLORIDE.

Synonyms.—*Chloride of Sulphur*, S_2Cl_2.

Source.—This compound is prepared by passing a current of dry chlorine gas over melted sulphur contained in a retort, and the resulting chloride of sulphur condensed in a cool receiver.

Characters.—A yellow volatile liquid possessing a characteristic, penetrating, and disagreeable odour. Its molecular weight is 135, and specific gravity 1.68, and boils at 280° F. It fumes on exposure to air, owing to its combination with moisture. It sinks in water, and is gradually decomposed into sulphurous and hydrochloric acids, together with free sulphur and polythionic acids. Sulphur is soluble in chloride of sulphur to the extent of nearly 70 per cent. It acts upon mercury and other metals, and combines with ammonia. It is corrosive in nature.

Uses.—Its principal application is as a solvent for sulphur for the vulcanisation of caoutchouc.

ZINC CHLORIDE.

Synonyms.—*Zincic Chloride*, *Chloride of Zinc*, *Zinci Chloridum*, $ZnCl_2$.

Source.—This salt is obtained by heating zinc in chlorine gas or dissolving the metal in hydrochloric acid, and evaporating the solution to dryness. Hydrogen gas is evolved, and chloride of zinc remains in solution.

Characters.—Anhydrous chloride of zinc is a greyish white, waxy-looking body, with a molecular weight of 136, and a specific gravity of 2.753. It fuses at 212° F., and distils at a red heat, and is soluble in water and alcohol. It is very deliquescent, and is a powerful dehydrant, charring wood, and converts alcohol into ether, and acts as a powerful corrosive upon the skin. A solution of zinc chloride is a solvent for silk.

Uses.—An aqueous solution of chloride of zinc, and known as "Burnett's disinfecting fluid," is often used as an antiseptic, and for preserving timber and vegetable fibre from decay. It is also applied in soldering for removing oxides from the surface of the metals during the process.

SECTION IV

GASES.

AMMONIA.

Synonyms.—*Volatile Alkali, Spirits of Hartshorn,* NH_3.

Source.—This gas is produced during the manufacture of coal gas, and is present in the "ammoniacal liquor" as a hydrate or in combination with other bodies as salts. It may be prepared in a pure state by heating the chloride or sulphate of ammonium with quicklime, and collecting the gas over mercury or by displacement. One ounce of chloride of ammonium (*sal ammoniac*) is capable of yielding 750 cubic inches of the gas.

Characters.—Ammonia is a colourless gas possessing a characteristic pungent odour and acrid taste. It will not support combustion, but is itself feebly combustible. If breathed in a concentrated form, it produces fatal results, although when largely diluted with air, it acts as a valuable stimulant and restorative. It has a molecular weight of 17, and is much lighter than air, its specific gravity being 0.59. When cooled to -40° F. with a mixture of snow and calcium chloride, it condenses to a liquid which boils at -37° F. Ammonia gas is extremely soluble in water, 1 volume of which absorbs over 700 volumes of the gas at the ordinary temperature (*see also* page 14). Liquefied ammonia dissolves sulphur, phosphorus, and iodine.

Uses.—Compressed or liquefied ammonia gas is stored and conveyed in cylinders, and is used in the production of ice, and general refrigeration purposes.

CARBONIC ANHYDRIDE.

Synonyms.—*Carbonic Acid Gas, Carbon Dioxide, Choke Damp,* CO_2.

Source.—This gas is produced by burning charcoal in oxygen, and is a product of the combustion of all organic materials, such as coal, wood, &c., in air. During the conversion of limestone (carbonate of lime) to caustic lime by roasting, over 40 per cent. of the gas is evolved. It is a constituent of volcanic emanations, the breath of animals, and gases resulting from fermentation of various organic liquids. It is prepared on the large scale by the action of sulphuric or hydrochloric acid upon chalk, limestone, or marble.

Characters.—Under ordinary atmospheric pressure, the gas is colourless and invisible, with a faintly acid smell and taste. It has a molecular weight of 44, and is 1.520 times as heavy as the atmosphere. It is not inflammable, neither will it support combustion. When present in air to the extent of 3 or 4 per cent., it acts as a narcotic poison if breathed, and would extinguish a lighted candle. Carbonic anhydride is soluble in water, to which it imparts a sharp though pleasant acid taste, to the extent of 1 part by volume at the ordinary temperature and pressure. By increasing the pressure, however, a proportionately larger volume of the gas is dissolved, but which escapes with effervescence when such pressure is relieved. An illustration of the kind of effervescence is observed when bottles containing aerated liquids, such as champagne, soda water, lemonade, &c., are opened, the pressure of gas in these bottled liquids being from 60 to 90 lbs. per square inch.

When carbonic anhydride is subjected to a pressure of 540 lbs. per square inch at a temperature of 32° F., it condenses to a colourless and very mobile liquid, boiling at −108° F.

at ordinary pressure, and having a specific gravity of .8266 at 68° F. The liquid expands greatly on being heated. The pressure that liquid carbonic anhydride would exert on cylinders on being raised in temperature from 32° F. is as follows :—

32° F. - - -	520	lbs. per square inch.
44° F. - - -	595	,, ,,
50° F. - - -	677	,, ,,
59° F. - - -	767	,, ,,
68° F. - - -	865	,, ,,
77° F. - - -	971	,, ,,
86° F. - - -	1085	,, ,,
95° F. - - -	1208	,, ,,
104° F. - - -	1338	,, ,,
113° F. - - -	1476	,, ,,

Liquid carbonic anhydride floats on water, but is soluble in all proportions of alcohol, ether, carbon disulphide, and naphtha. When the liquid is suddenly relieved from pressure, the loss of heat consequent upon vaporisation solidifies the remaining liquid to a white snow-like mass, which is much colder than the liquid; and if a flake of the solid be pressed on the skin, it raises a blister as if produced by a burn.

Much care should be exercised as to the carriage of liquid carbonic anhydride, since great pressure is developed for but slight differences in temperature. The approved steel or wrought iron cylinders (*see* page 39) used to convey the liquid or compressed gas should not be allowed to be exposed to the sun's rays, or to be in proximity to any hot body. The danger involved by the bursting of a cylinder of the liquid would be damage by the flying pieces of iron, and possible suffocation by the disengagement of a large volume of irrespirable gas.

Uses.—Carbonic acid gas is largely used in the manufacture of aerated drinks, such as soda water, lemonade, seltzer water, and has been applied with considerable success in conjunction with steam as a fire extinguisher, and in the solid and liquid state it is used for the production of low temperatures for various purposes.

CHLORINE.

Synonym.—*Cl.*

Source.—Chlorine is found abundantly in nature in combination with sodium as common salt, from which it may be prepared by mixing with manganese dioxide and heating with sulphuric acid. It is prepared on an enormous scale for the preparation of bleaching powder by acting upon manganese dioxide with hydrochloric acid, chloride of manganese and chlorine gas being produced.

Characters.—Chlorine is a transparent greenish yellow elementary gas of a characteristic suffocating odour. Even when largely diluted with air and breathed, it irritates the air passages and produces coughing. It has an atomic weight of 35.5, and is 2.45 times as heavy as air. 100 cubic inches of the gas at 60° F. and 30″ Bar. weighs 77.5 grains. Under a pressure of 120 lbs. per square inch at 60° F., it condenses to a yellow limpid liquid of 1.33 specific gravity, and at very low temperatures it solidifies. Water dissolves about twice its volume of the gas at the ordinary temperature. Chlorine is a chemically active gas. It is not inflammable, but will support the combustion of certain substances. A lighted taper continues to burn with a reddish smoky flame when plunged into the gas. When phosphorus, and finely divided metals, such as antimony, arsenic, and copper, come into contact with the gas, they spontaneously burst into flame with the formation of their chlorides. Many organic substances are attacked in the same manner. A piece of paper saturated with turpentine inflames when in contact with the gas, and deposits a large quantity of a sooty substance. It has powerful bleaching and disinfecting qualities, caused by its affinity for hydrogen in organic matters, and liberating nascent oxygen, or by the production of *substitution products.*

Uses. — For the manufacture of bleaching powder or chloride of lime. As a deodorant, disinfectant, and bleaching agent. Liquid chlorine is now much produced for these purposes, and is stored and conveyed in mild steel cylinders under the same conditions as the other kind of compressed or liquefied gases.

HYDROGEN.

Synonyms.—*Inflammable Air, H.*

Source.—This gas may be obtained in a variety of ways, the following of which are examples:—

(1.) By decomposing water by the metals potassium or sodium.

(2.) By passing steam over red-hot iron turnings.

(3.) By decomposition of water with electricity.

(4.) More conveniently by the action of sulphuric acid upon metallic zinc.

(5.) Coal gas contains between 40 and 50 per cent. of hydrogen.

Characters.—Pure hydrogen is an elementary gas, invisible, tasteless, and odourless. It is inflammable, and burns in air with a slightly bluish flame, with the production of water as steam. It is much lighter than the atmosphere, its specific gravity compared with air being 0.0692, or 14.44 times as light, and 100 cubic inches of the gas at 60° F. and 30″ Bar. weigh only 2.14 grains. It is the lightest substance known, and is taken as the unit or standard of comparison for atomic weights and combining volume. Hydrogen, when mixed with half its volume of oxygen, or 2½ its volume of air, constitutes a highly explosive gas, and great care should be taken that hydrogen when intended to be ignited should be free from air. Hydrogen during its combustion in oxygen gives out most intense heat, the temperature during combination being about 5000° F. Advantage is taken of this high temperature to melt highly refractory materials or metals, such as platinum, and also for raising lime to incandescence, and which produces a most dazzling and brilliant light, known as the oxyhydrogen limelight, much used by lecturers, &c. The gases used are kept separate in bags, or compressed in metallic cylinders, and the oxygen is supplied to the scene of combustion by a separate tube fixed at right angles immediately beneath the burner through which the hydrogen passes. Coal gas is often substituted for hydrogen in the production of limelight.

Hydrogen is soluble in water to the extent of about 2 per cent. by volume, and the solubility is unaffected by differences of temperature. It has no poisonous properties, but will not support respiration, although when a small quantity is mixed with air it may be breathed without causing inconvenience, giving a squeaking and shrill sound to the voice by reason of its tenuity. Hydrogen, like all other gases, can now, when subjected to intense pressure and very low temperature, be liquefied.

Uses.—The principal use of this gas is for the production of the oxyhydrogen light and lecture demonstrations, for which purpose it is conveyed compressed in wrought-iron or steel tubes of approved quality and strength (*see* page 313).

MARSH GAS.

Synonyms.—*Light Carburetted Hydrogen, Methane, Sub-carburetted Hydrogen, Methyl Hydride, Fire Damp,* CH_4.

Source.—Marsh gas occurs in nature during the decay of organic matter, and is produced during the conversion of vegetable matter into coal. It is frequently met with in coal mines mixed with air, and known by the miners as *fire damp*, which is the cause of most of the disastrous colliery explosions we hear of. Ordinary coal, when fresh, will evolve considerable quantities of occluded marsh gas. It is a constant constituent of the gases emanating from stagnant pools and marshes, and is generally present in coal gas to the extent of about 30 per cent. It is prepared artificially by heating acetate of sodium with caustic soda, or by passing the mixed vapours of bisulphide of carbon and sulphuretted hydrogen over red-hot copper.

Characters.—Marsh gas is colourless, tasteless, and without odour. It is a hydrocarbon, contains 25 per cent. of hydrogen, and contains more hydrogen than any other compound of this element. It has a molecular weight of 16, and is much lighter than air, its specific gravity being 0.553. It is inflammable, and burns with a yellowish, feebly illuminating flame. It will not, however, support combustion. Under the influence of very low temperatures and great pressures it is liquefied. Next to hydrogen, it is the lightest body known. It is but slightly soluble in water or alcohol. When mixed with 2 volumes of oxygen or 10 volumes of air it constitutes a highly explosive mixture. This is the *fire damp* of the miner. In addition to the violence of an explosion by this mixture in a coal mine, the products of combustion being carbonic anhydride and steam (*choke damp or after damp*), there are probably as many deaths due to suffocation by the after-products as from the explosion itself. Marsh gas is important from a theoretical point of view as being the initial base or start point of the methane or paraffin series of hydrocarbons.

Uses.—Pure marsh gas has but few applications. Used by lecturers for demonstrating causes of explosions in coal mines, &c.

NITROUS OXIDE.

Synonyms.—*Protoxide of Nitrogen, Nitrogen Monoxide, Laughing Gas,* N_2O.

Source.—This gas is prepared by the decomposition of ammonium nitrate by heat, nitrous oxide and steam being produced.

Characters.—Nitrous oxide is a colourless gas, with a faint odour and sweetish taste. Its molecular weight is 44, and is 1.525 times as heavy as the atmosphere, and consists of 63.64 per cent. of nitrogen, and 36.36 per cent. of oxygen. It is not inflammable, but will support combustion. A glowing match bursts into flame when plunged into the gas. When breathed for a little while, it has a remarkable effect upon the system, producing a species of intoxication and insensibility. 100 volumes of water at the ordinary temperature dissolve 77 volumes of the gas. Under a pressure of 50 atmospheres at 45° F. it condenses to a colourless liquid, having a specific gravity of 0.908, and boiling at –126° F. It solidifies to a snow-white mass when cooled to about –150° F. The liquid, when placed upon the skin, raises a blister like a burn. When mixed with bisulphide of carbon, and evaporated in a vacuum, intense cold is produced, calculated at –220° F.!

Uses.—The principal use of the gas is as an anæsthetic by surgeons and dentists, and also used in lecture demonstrations.

OIL GAS.

Synonyms.—*Pintsch's Gas*, *Pope's Gas.*

Source.—This gas is extensively produced from paraffin oil, from shale, and also from certain fractions of petroleum. The oils are run into red-hot retorts in a continuous stream, and the resulting gas conveyed to a gas-holder, from whence it is drawn (when intended for lighting railway carriages) into strong metallic cylinders, and compressed up to about 200 lbs. per square inch. During the compression a considerable quantity of the heavier hydrocarbons present condenses to a thin mobile liquid, known as *hydrocarbon*, and which is very volatile and highly inflammable. The average amount of gas produced from a ton of paraffin oil is about 22,000 cubic feet, having a candle power of about 60.

Characters.—Oil gas is colourless, and burns with an intensely luminous flame, giving about 3½ times as much light as ordinary coal gas. It has a peculiar and disagreeable odour, and consists of a number of heavy hydrocarbons, notably ethylene (C_2H_4).

Uses.—The principal use of this gas is for lighting railway carriages. It is stored in cylinders (underneath the carriages), and compressed to about 200 lbs. per square inch. The pressure of the issuing gas is regulated by "governors," and each burner generally consumes about 1½ cubic feet of gas per hour. Oil gas is sometimes used for enriching poor coal gas.

OXYGEN.

Synonyms.—*Vital Air, O.*

Source.—This gas is the most widely diffused of all the elements. It constitutes one fifth by volume of the atmosphere, and in combination with various other bodies it constitutes nearly 50 per cent. of the weight of the globe. Water contains about eight-tenths of its weight of the gas in combination with hydrogen. Pure oxygen can be prepared in a variety of ways, of which the following is a list:—

(1.) By heating red oxide of mercury, metallic mercury and oxygen gas are produced.

(2.) By heating chlorate of potash, when chloride of potassium and oxygen are produced.

(3.) By heating peroxide of manganese, tetraoxide of manganese and oxygen being produced.

(4.) By heating bichromate of potash with sulphuric acid, sulphate of chromium, hydro-potassic sulphate, and oxygen being formed.

(5.) Large quantities of oxygen are now produced from the atmosphere by what is known as Brin's oxygen process, which is founded on the fact that when protoxide of barium (BaO) is heated in air to about 1000° F., oxygen is absorbed with the formation of peroxide of barium (BaO_2) and nitrogen gas, and the higher oxide on being further heated to about 1700° F. evolves the oxygen that was absorbed, and passes into its original condition of protoxide, which, on cooling to 1000° F., again absorbs oxygen, which may be evolved on heating as before. The Brin Oxygen Company now manufacture the gas by keeping the barium monoxide contained in vertical retorts heated to a uniform temperature of 1350° F. Purified air at a pressure of 10 lbs. per square inch is then admitted. Oxygen is thus absorbed, and which is afterwards recovered by subjecting the retorts to a vacuum of 26 inches of mercury.

Characters.—Oxygen is a colourless, odourless, and tasteless gas. It is not inflammable, but is an intense supporter of combustion. Substances which burn in air burn in oxygen with increased brilliancy. Oxygen is an essential supporter of animal life and combustion. It has an atomic weight of 16, and is 1.1056 times as heavy as the atmosphere, 100 cubic inches of the gas at 60° F. and 30 inches pressure weighing 34.203 grains. It is slightly soluble in water, which absorbs $\frac{1}{33}$ its bulk at 60° F., and about $\frac{1}{25}$ at 32° F. Atmospheric oxygen plays an important part in the development of heat in goods liable to "spontaneous" combustion. Oily rags, coal, hayricks, &c., absorb atmospheric oxygen so rapidly (under favourable conditions) as to raise the temperature of the material to the ignition point. Many disastrous conflagrations have been traced to this cause. Application of great cold and high pressure condenses oxygen to a colourless mobile liquid of specific gravity 0.65.

Uses.—Pure oxygen is much used for the production of the oxyhydrogen flame, for melting refractory substances, and for the limelight. It is used in lecture demonstrations, and in the analyses of gases, and has been much applied of late for inhalation in certain diseases. It has also been suggested for use in mines. It is conveyed by railways in mild steel or wrought-iron cylinders $5\frac{1}{2}$ inches external diameter and $\frac{1}{4}$ inch thick, provided with screw stopcocks, and is generally compressed up to 120 atmospheres.

SULPHUROUS ANHYDRIDE.

Synonyms.—*Sulphur Dioxide, Sulphurous Acid,* SO_2.

Source.—This gas is prepared in a variety of ways:—

(1.) By heating sulphur in air or oxygen, or with metallic peroxides.

(2.) By roasting the pyrites of iron or copper in air or oxygen.

(3.) By heating copper or carbon with sulphuric acid.

(4.) By heating anhydrous ferrous sulphate with sulphur.

Characters.—Sulphurous anhydride is a colourless gas, with a suffocating pungent odour, characteristic of burning sulphur. If the gas is breathed, even when largely diluted with air, it affects the respiratory organs, giving rise to symptoms of catarrh. It has a molecular weight of 64, and is about $2\frac{1}{4}$ times as heavy as the atmosphere. It is not inflammable, neither will it support combustion. It is very easily liquefied. Under a pressure of 3 atmospheres at 60° F., or by cooling the gas to 0° F. with a mixture of snow and ice, it condenses to a thin, yellowish, mobile liquid of a specific gravity 1.45, with a boiling point of 14° F. If the liquid is further cooled in a mixture of solid carbon dioxide (carbonic acid gas) and ether, it becomes converted into a transparent solid, melting at −110° F.

Sulphurous anhydride is very soluble in water, with which it forms sulphurous acid. One part of water at 50° F. takes up about 51 volumes of the gas, and at 70° F. 35 volumes are absorbed. On warming the liquid, sulphurous anhydride gas is evolved. The liquid is strongly acid, and is corrosive and poisonous. It is a powerful reducing and bleaching agent. On exposure to the air, the liquid gradually becomes converted into sulphuric acid.

Uses.—Sulphurous acid is extensively employed for bleaching silken goods, sponges, isinglass, wood, straw, &c. It is a valuable antiseptic and disinfectant. Rooms, such as fever infected hospital wards, infected clothes, &c., are very effectually disinfected by the fumes from burning sulphur. It is also used to check fermentive growth in certain liquids, such as cider or wines. The formation of the gas is also the preliminary step in the production of sulphuric acid on the large scale, obtained either by the roasting of sulphur or metallic sulphides. The liquid sulphurous anhydride gas, contained in strong glass syphon bottles provided with a stopcock, is now largely used in chemical laboratories for reduction purposes and for lecture demonstrations. The liquid is of course under pressure, and on relieving the stopcock a copious supply of the gas can be conveyed where desired by a tube.

CYLINDERS FOR THE STORAGE AND CONVEYANCE OF COMPRESSED GASES

The following is a description, by Mr Murray, of the cylinders used by the Brin Company for the storage and conveyance of compressed oxygen, which also applies to other gases :—

To users of compressed gases and to the public generally, the cylinders employed for transporting the gas are naturally of more interest than the compressor which fills them. Much has been written both in technical journals and ordinary newspapers about the safety of gas cylinders. It has frequently been suggested that the manufacture and testing of cylinders should be carried out under State control, and that only those bearing a Government test mark should be employed for the transport of gases. This system has already been adopted abroad, and to none probably would its adoption in this country be more welcome than to gas compressing companies, who would thereby be relieved in a great measure of the most onerous duty in connection with their business.

It is possible that sooner or later, as the trade in the transport of compressed gases develops, some kind of Government inspection will be adopted, and meanwhile it behoves all owners of cylinders, whether they be private individuals or public dealers, to employ only the best and most trustworthy article, so that should such a time come, their stock will be found to comply with all reasonable requirements.

If certain conditions as to (1) uniformity of pressure, (2) quality of material, thickness and shape of cylinder, (3) testing, and (4) non-interchangeability for different gases, are invariably followed, we are convinced that the transport of gases can be conducted with absolute safety, and that so far from the danger increasing proportionately with the growth of the trade, it will diminish as the older and less reliable class of cylinders gives place to new and improved types.

The trade in compressed gases is no new one. Iron gas cylinders of a heavy and unreliable kind were introduced into this country about a quarter of a century ago, for the storage and transport of nitrous oxide and carbonic acid. These gases liquefy under average atmospheric conditions at pressures of about 30 and 36 atmospheres respectively. The pressure, therefore, to which cylinders were charged was low as compared with that now employed. With the development of oxygen, and the demand for large quantities of that gas, an infinitely better type of cylinder has come into the market, with the result that the old heavy iron ones are rapidly disappearing. The Brin Oxygen Company has been mainly instrumental in bringing this satisfactory change about, and as the types and sizes of cylinders sold by that company have become the recognised standards throughout the trade, a description of them will be of interest.

Construction of Compressed Gas Cylinders.

All the cylinders employed by the Brin Oxygen Companies are made of mild steel, and are either lap-welded or seamless. They are all similar in appearance, but vary in size according to their cubic capacity. The lap-welded cylinders are made from ordinary rolled and welded tubes, which are cut to the length required, then welded up solid in a spherical shape at one end, and finally swaged or drawn down at the other end on to a dovetailed ferrule which is screwed to receive the valve. The seamless cylinders are either made from seamless tubing, which is cut to the length required, and has the ends closed in exactly the same manner as in the case of lap-welded cylinders, or else they are made from a circular steel slab containing the requisite amount of metal to ultimately make the size of cylinder required.

This latter is the type popularly known as the solid-drawn cylinder. The slab is repeatedly heated, and pressed by hydraulic power on various mandrels, through dies, until the form is nearly obtained. It is then drawn cold to the finished size, and carefully annealed in order to restore the metal to its original state of ductility. In this way a tube open at one end, but closed spherically at the other, is obtained; and, finally, the neck is formed as in the case of the other cylinders.

All the cylinders supplied by the Brin Companies are made to contain certain convenient quantities of gas at a pressure of 120 atmospheres, this being the standard filling pressure at present employed. Cylinders are made of all lengths, but their thickness varies only with their diameters and type. Thus the *minimum sections* now employed by the companies are as follows:—

4	inches	external	diameter,	seamless	type, are	$\frac{5}{32}$	inch thick.
$5\frac{1}{2}$	,,	,,	,,	,,	,,	$\frac{7}{32}$	,,
$5\frac{1}{2}$	,,	,,	,,	lap-welded	,,	$\frac{1}{4}$	,,
7	,,	,,	,,	seamless	,,	$\frac{9}{32}$	,,

Good cylinders of other diameters and thicknesses are in use, but the above are the most popular, and the general tendency of the trade is to adopt these diameters exclusively.

As regards the ultimate strength of cylinders, many tests have been made in order to ascertain their bursting point and elastic limit, and as they are now all constructed of nearly proportionate strength, the results may be generally summarised as follows:—

Pressure per square inch at which cylinders burst.

Lap-welded	$2\frac{1}{2}$ to 3 tons.
Seamless	$2\frac{1}{2}$,, 3 ,,
Expressed in atmospheres	373 ,, 448 ,,

Limit of elasticity per square inch of metal.

Lap-welded	16 to 18 tons.
Seamless	20 ,, 23 ,,

Ultimate tensile strength per square inch of metal.

Lap-welded	25 to 27 tons.
Seamless	29 ,, 33 ,,

The quality of metal in cylinders varies but little, and ductility is practically ensured by annealing, and by employing only a mild quality of steel.

The following tests were made with a view to ascertaining the amount of rough treatment which a cylinder would stand without bursting, and the place selected for conducting these somewhat perilous experiments was a pit at Stevenstown, near Glasgow.

Three cylinders selected from the Brin Company's ordinary stock were taken. They were all of a standard type, viz., $5\frac{1}{2}$ inches external diameter by $\frac{1}{4}$ inch thick. Nos. 1 and 2 (Fig. 1) were charged with 120 atmospheres of oxygen in the usual way. No. 3 was filled with liquefied carbonic acid.

No. 1 cylinder was twice raised to a height of 35 feet, and dropped horizontally upon a solid iron block 12 inches square, each blow bending the cylinder to the extent of about $\frac{3}{4}$ of an inch. It was then dropped vertically on its spherical end, having a clear fall of 31 feet, when it was found that the impact had only flattened a part of about the size of a penny piece. It was crushed with a 15 tons blow, received whilst it lay across an iron block, and it was finally bent with the same blow into the shape shown whilst it was supported on two anvils set 4 feet apart.

No. 2 cylinder was dropped horizontally across an anvil five times from a height of 35 feet, receiving the blow each time on the same spot.

No. 3 was dropped twice from a height of 35 feet, and then crushed into the shape shown by a 15 tons blow. On these cylinders being subsequently tested, they were found to contain the *full quantity of gas.*

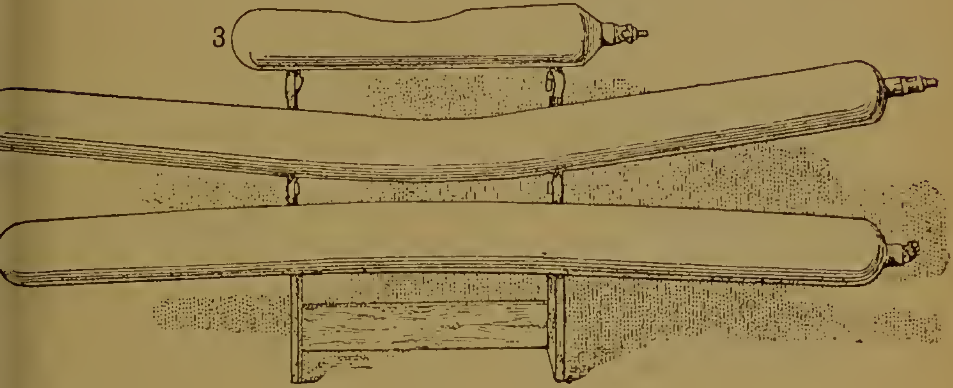

Fig. 1.

Experiments with Lap-welded Cylinders.

Many stringent experiments have also been made with seamless cylinders, and perhaps the best evidence of their strength is recorded by Professor Goodman, of the Yorkshire College, Leeds, in a report which he published in the end of 1893. We will quote from his report, and may add that the cylinder in question was of the solid-drawn type, and had been procured in the ordinary way from one of the Brin Companies.

"The cylinder, when fully charged with oxygen, was dropped through a height of 22 feet on to a block of cast-iron. It alighted on its bottom end, and was *very slightly* indented, so slightly that few were able to detect the dent until it was pointed out. After discharging the oxygen, the cylinder was subjected to an internal hydraulic pressure of 2 tons per square inch, which was left on for about a quarter of an hour. No bulging or distortion could be detected by careful measurements. The cylinder was then considered safe, and was returned to the Oxygen Company to be refilled. On its return the cylinder was again dropped through a height of 22 feet, and another very slight dent produced. The cylinder was then taken to the top of the Engineering Department of the College, and was twice dropped through a height of 50 feet. The first time it alighted on a sharp corner of the cast-iron block, and the second time on the flat surface of the block. The only result of dropping was to produce two small dents. The cylinder was then laid flat on the table of the testing machine, and a sharp V block pressed into it with hydraulic pressure in order to find to what depth the cylinder might be dented before giving way. The pressure was gradually increased until the cylinder (4 inches diameter) was squeezed almost flat, and the V block had made a dent 2¼ inches deep. It then suddenly tore apart along both sides, producing a loud report, but without dislodging a single loose fragment. The cylinder, although torn, was still in one piece."

All gases are subject to the law that pressure increases uniformly with the temperature when the volume remains the same. It is an easy matter, therefore, to calculate the actual increase or reduction of pressure for every measurable degree of temperature.

The co-efficient of expansion for 1° F. may be taken as 0.00203 of the volume at 32° F. If 120 atmospheres be taken as the pressure in a cylinder at a temperature of 60° F., then the following table represents the pressure at a few different temperatures :—

60° F.	120.00	atmospheres
70°	122.33	,,
80°	124.64	,,
90°	126.86	,,
100°	129.26	,,
150°	140.85	,,
212°	155.21	,,

Extremes in temperature should always be avoided, and the cylinders must not be exposed to the direct rays of the sun or any heated body.

The following rules to all who employ compressed gases in connection with the limelight are issued by the Brin Oxygen Company:—

Ordering Gas—

(1.) Order your cylinders some days before they are required for use. State clearly the amount of gas you want, and fittings required.

(2.) If cylinders are procured from a Brin Company, see that you apply to the company in whose district you reside. Also note the type of valve which will be supplied on both oxygen and coal gas cylinders, so that if you have gauges, regulators, or other fittings of your own, you may know in good time whether they will fit the cylinders which will be sent to you.

(3.) The Brin Companies lend out cylinders, valve keys, and nipple-and-unions. Pressure gauges, regulators, and other fittings must, however, be purchased from them.

Private Cylinders—

(4.) If you are a constant user of compressed gases you will find it cheaper and better to buy your own cylinders and fittings, and send the former when necessary to your agent or the Compressing Company of your district to be filled.

(5.) The Brin Companies anneal and then test all cylinders received for the first time to a standard hydraulic test pressure, and they register and stamp with their respective marks (before filling with gas) all cylinders which have been proved sound under treatment.

(6.) All cylinders are periodically re-tested by the Brin Companies at their own discretion, but never at shorter intervals than one year.

(7.) No coal gas cylinders are filled by the Brin Companies unless they are *painted red*, and are fitted with recognised types of *non-interchangeable valves.*

Gauging Contents of Cylinders—

(8.) When cylinders arrive from the Compressing Company, gauge them, to see that they contain the full quantity of gas. Sometimes in transit valves are jarred, so as to start a slight leak of gas, which can generally be stopped by screwing down the valve spindle a little tighter.

(9.) For gauging cylinders, use *separate* gauges for oxygen and coal gas, and it is desirable to have the former at any rate fitted with a safety check. Before screwing up the gauge so as to form the joint with cylinder valve, open the latter slightly. This prevents any sudden impact of gas through the jerky opening of a stiff valve.

Testing for Leakage—

(10.) After gauging the cylinder, or, if a cylinder is not gauged, the moment it comes to hand, test the valve with *water*, either by complete immersion, or by pouring a small quantity into the valve outlet. If *no bubbles show in the water*, you can rest satisfied that all is gas-tight. Repeat this test *always* after using gas until the cylinder is empty.

(11.) It is desirable to test round the valve spindle *when the valve is open* in the same way, and if any leak is found, tighten down the gland nut.

Cylinder Fittings—

(12.) If you use your own fittings in connection with hired cylinders, it is well to try them on arrival of cylinders to make sure that everything is accurate.

(13.) Never use fittings with taper screwed connections, such as are supplied by certain makers. They are unreliable, unmechanical, and most injurious to valve connections.

(14.) If possible, always use regulators on your cylinders.

The combined pressure gauge and regulator fitting is best, as you then know exactly how your gas supply is lasting.

(15.) Pressure gauges require readjustment periodically, according to the amount of use and treatment they are exposed to.

Jets—

(16.) When regulators are used, all adjustment of gases can be done by the taps on the jet.

(17.) When *no* regulators are used, and gas is taken direct from the cylinders, all adjustment must be done by means of the cylinder valves, or fine-adjustment valves, if these are employed. *The taps on the jet must be opened fully, and no regulation attempted by means of them.*

(18.) Never attempt to work "Bi-unial" or "Triple" lanterns direct from cylinders, *i.e.*, without regulators.

(19.) If with a single lantern gas is taken direct from cylinders (without regulators), a blow-through jet will be found the most convenient.

(20.) If coal gas is taken from the house supply direct, and oxygen from a cylinder—*without a regulator*—a blow-through jet should always be used.

Limes—

(21.) Fix limes only after everything is prepared, so as to avoid exposure to the atmosphere when they are cold as much as possible.

(22.) Adjust the lime about ½ inch in front of the nozzle of a blow-through jet, and about ⅛ inch in front of nozzle of a mixed jet.

(23.) Turn on the coal gas first, and heat the lime well before turning on the oxygen.

(24.) The best proportion of gases is that which gives the best light. There should be no flame visible, and little or no noise.

(25.) Do not leave one surface of the lime exposed to the jet for too long a time.

(26.) In turning off gases, always turn off the oxygen first.

(27.) Do not leave your lime to decompose in the lantern.

Oil—

(28.) *Avoid the use of oil or lubricant in any form*, and keep all joints and working parts free from grit and lime dust.

Position of Cylinders—

(29.) If possible, always use the cylinders in a vertical position. By so doing there is far less likelihood of moisture or grit—that may be in a cylinder—getting blown into the valve, or other passages, or against the lime. This is especially desirable in the case of coal gas.

Return of Empty Cylinders—

(30.) Return hired cylinders to the owner whenever they are done with, and thus avoid paying rent on them. Also return any fittings which have been lent with the cylinders, otherwise they will be charged for.

Returned Gas—

(31.) The Brin Companies allow no credit for returned gas. They have an invariable rule of blowing away all gas returned in cylinders. It is well to note, therefore, that gas returned is gas wasted. Oxygen never deteriorates by being kept in cylinders.

Compressed Coal Gas.

The methods of compressing oxygen and coal gas ar similar, but it is needless to add that independent compressor and pipe connections are used for each gas.

Coal gas is taken from the ordinary supply main, and i compressed into cylinders in the usual manner. An inte mediate chamber of some kind is generally placed between the main and the compressor, the object of which is to prevent the pulsations of the compressor affecting the ordinary gas lights in its immediate vicinity.

The terms coal gas and hydrogen, when employed in connection with limelight, are often used as if they were synonymous, and an oxy-coal-gas limelight is generally found as satisfactory as an oxyhydrogen one. The composition of coal gas, however, makes its compression rather more difficult and uncertain than that of pure hydrogen. Coal gas is composed mainly of hydrogen and carburetted hydrogen, and the intrinsic luminosity of a coal gas flame depends on the relative proportion of these gases, the highest illuminating power being obtained under ordinary conditions from the gas which possesses the most carburetted hydrogen. During compression coal gas loses a considerable proportion of its intrinsic luminosity. This is due to the fact that many of the less volatile hydrocarbons are condensed, and deposited in the form of a tarry liquor, when the gas is subjected to pressure. Luminosity, however, is not required of coal gas which is used for limelight purposes. It is on the heating power created by the combustion of the gas in oxygen that the light depends. Oxygen and hydrogen in combustion produce the highest temperatures known, and as coal gas of the poorest intrinsic luminosity generally contains the highest percentage of hydrogen, it may even be argued that a gas of poor illuminating power is often the best for limelight work. Any condensation of hydrocarbons during compression means an increased proportion of hydrogen, and consequently, on the same grounds, it may be said that coal gas will produce greater heat in combustion with oxygen, after compression into cylinders, than before.

The greater part of the tarry liquor produced by this condensation of hydrocarbons is drawn off at the separator on the compressor, but a small proportion generally finds its way into cylinders, and if compressed coal gas is kept in cylinders for any great length of time, a further slight condensation takes place. To prevent the accumulation of this liquor, a very good plan is to disconnect the cylinder from the lime jets before all the pressure has run down. Then take it outside, and, holding it with the valve downwards, allow the remainder of the gas to blow away into the atmosphere. The Compressing Companies invariably adopt this method when cylinders are returned with any gas in them, and as the liquor is driven out by the gas, this is generally found sufficient to keep the cylinders in good working order. If users of compressed coal gas observe this precaution with regard to their cylinders, and if they make it an invariable rule to work with their cylinders in a vertical position, the hydrocarbon deposit will give them little or no trouble, and blocking of valve passages and discoloration of limes, sometimes attributable to this cause, will be avoided.

There is another compound sometimes formed by the compression of coal gas which causes discoloration of limes, and which it is more difficult to guard against.

Coal gas invariably contains a small percentage of carbon-monoxide, and it has recently been discovered that this gas slowly combines with the iron of the cylinder, forming a volatile compound—viz., iron-carbonyl. At the first glance, it might appear as if this action must have serious results as regards the strength of the cylinder. This, however, is not the case. The combination takes place very slowly, and to an almost imperceptible extent. Practical experience points to the fact that it is only in isolated cases, and particularly where the compressed gas has been allowed to stand in the cylinder for a long time, that this compound is formed in sufficient quantity to make a deposit of iron on the lime. Indeed, the question from a practical point of view might be ignored altogether, except as a solution of the red deposit which is sometimes formed on limes.

It is probable that the condition of a cylinder, and even the composition of its metal, play an important part in the formation of the compound. We have known coal gas to stand in a solid-drawn steel cylinder for six months, and when used, no trace of the compound showed itself on the lime. On the other hand, we have heard of cases where deposits o iron oxide have been found on limes after the gas had been compressed into cylinders for only twenty-four hours. It is difficult to account for such conflicting results on any other basis than that the internal surface of the cylinder in one case was in a condition to combine with the monoxide, while in the other case it was not. The old types of iron cylinders, which are now fortunately almost extinct, were more liable to this action than the steel ones which have superseded them, and the reason probably was that the internal surface of the cylinders in the former case was rough and irregular, whilst in the latter it is smooth and uniform.

It is alluded to this question of deposit on limes, as it is a matter to which some prominence has lately been given in technical journals. The cases which occur are few in number, and the remedy which the Brin Companies have adopted is to remove the valve and heat the cylinder to a red heat. This has the effect of burning out all extraneous matter, whilst it does not appreciably injure the metal. The treatment appears to be efficacious, and need not be repeated, except perhaps at very long intervals. We would therefore advise any user of compressed coal gas who is troubled with serious discoloration of his limes to adopt this course.

The following rules are recommended as specially applying to compressed coal gas :—

Storing Coal Gas—

(1.) Avoid storing coal gas in cylinders any great length of time.

Testing for Iron-Carbonyl—

(2.) Burn a small flame of gas against a piece of white china or porcelain for a minute. If there is no dark deposit on the china at the end of that time the gas may be taken as good.

Discoloration of Limes—

(3.) If troubled with serious discoloration of limes, instruct your Gas Compressing Company to burn out the coal gas cylinder, the first time you send your cylinders in to be filled.

Position of Cylinders—

(4.) When cylinders are in use, it is most important to have the coal gas one in a vertical position (valve uppermost).

Cleaning Cylinder—

(5.) Always save a little pressure in your cylinder, and then either take it into the open air and blow it off with *valve downwards*, or return it to your Gas Compressing Company to be treated in this way. By this means the tarry liquor will be driven out.

SECTION V.

INFLAMMABLE LIQUIDS.

(A.) COAL TAR AND ITS PRODUCTS.

COAL TAR.

Synonyms.—*Gas Tar, Pix Liquida.*

Source.—Coal tar is obtained during the distillation of coal in the manufacture of coal gas. The tar, together with ammoniacal liquor, rises with the gas from the retorts, and is condensed in the hydraulic main, scrubbers, condensers, &c. The yield of tar averages about 12 gallons per ton of coal used. Tar is also obtained as a by-product in the manufacture of coke, and from certain blast-furnaces.

Characters.—Coal tar is a black viscous liquid, possessing a characteristic odour. Its specific gravity varies from 1.1 to 1.2, and generally gives off inflammable vapours at the ordinary temperature of the atmosphere. In composition it is one of the most complex liquids known, and contains about 150 different substances, present in more or less quantities—consisting of gaseous, liquid, and solid hydrocarbons, water, oxygenated compounds such as alcohols, carbolic acid, &c., chlorinated and nitrogenous compounds. The percentage composition of tar, however, greatly depends upon the nature of the coal used and also the temperature at which it was formed. The lower the temperature, the more tar and less gas is produced. High temperature decomposes tar vapours, forming further quantities of gas. The following table gives a list of the principal constituents of tar when subjected to fractional distillation :—

Synopsis of Coal Tar Distillation.

Dehydration, *a.* by standing - - - -
b. during the heating up - -
Distillation.
I. *Fraction up to* 340° F. { Ammoniacal liquor
First runnings } **Ammoniacal Liquor.**

rectified yield—
(1) Product up to 230° F., chemically washed,
Distilled by steam, yields, *a.* -
b. Weaker benzol goes to 1, 2 -
(2) Product up to 285° treated like (1),
yields, *a.* - - - - - } **90 per cent. Benzol.**
b. - - - - - **50 per cent. Benzol.**
c. Intermediate fraction is redistilled
d. - - - - -
(3) Product up to 340° treated like (1) and
(2) yields, *a.* - - - - } **Solvent Naphtha.**
b. - - - - **Burning Naphtha.**
c. Residue goes to II.

II. *Fraction from* 340° to 446°. Middle Oil washed with caustic soda yields—
(1) Oil, distilled in the light oil still, yields—
a. Distillate up to 340° goes to (1), (3)
b. Distillate up to 446° yields - **Naphthalene.**
c. Residue goes to III.
(2) Alkaline liquor decomposed by CO_2 yields—
a. Aqueous solution of sodium carbonate, causticised by lime and used over again
b. Crude carbolic acid is purified
and yields, *α.* - - - } **Carbolic Acid.**
β. Waste oils go back to II.

III. *Fraction from* 446° to 520° = *Heavy oil* (collected till solid matters begin to crystallise).

Can be treated for naphthalene, usually only employed as - - - - **Creosote Oil.**

Or else separated into *a.* - - -

b. - - - **Lubricating Oil.**

IV. *Fraction, anthracene oil*

Filtered or cold-pressed yields—

(1) Oils are redistilled and yield—

a. Solid distillate, treated along with IV. (2)

b. Liquid distillate, goes to III. *b*, or is redistilled.

c. Residue (pitch, coke, &c.)

(2) Residue is hot-pressed and yields—

a. Oils treated like IV. (1)

b. Crude anthracene washed with naphtha, &c., yields, *α.* - - **Anthracene.**

β. Solution is distilled and yields—

aa. Naphtha used over again for washing

bb. Phenanthrene, &c., is burnt to **Lampblack.**

V. Pitch, employed for patent fuel or varnishes, &c. - - - - - - - **Pitch.**

Or else distilled, yielding—

(1) Crude anthracene treated like IV. (2)

(2) Lubricating oil goes to III. *a*, resp. III. *b*.

(3) Residue - - - - - - - **Coke.**

The following table shows the yields in percentages of the various products from different tars:—

	Light Oil.	Neutral Heavy Oil.	Phenol, or Carbolic Acid.	Paraffin	Naphthalene.	Pitch.
Boghead - - -	12	30	3	41	...	14
Cannel Coal - -	9	40	14	...	15	22
Newcastle Coal -	2	12	5	...	58	23
Staffordshire Coal -	5	35	9	...	22	29

Uses.—The uses of this important substance are very numerous, the following being a list of its principal applications :—For distillation, to recover its valuable ingredients; for preservation of building materials of all kinds, wood, stones, brickwork, &c.; for the manufacture of roofing felt, for covering sheds, factories, &c.; for gas-making; as a liquid fuel for raising steam in stationary and locomotive boilers; for making patent fuel, lampblack, and printers' ink; extensively employed to bind the basic materials used in the lining of the "converters" in the basic steel process.

BENZENE.

Synonyms.—*Benzol*, C_6H_6.

Source.—Principally obtained in the distillation of coal tar, and found in the fraction that distils up to 285° F. It is separated from the ammoniacal liquor upon which it floats, then chemically washed, and redistilled by steam.

Characters. — Benzene is a colourless, volatile, mobile liquid, of a tarry smell. It boils at 177° F., and freezes at 32° F., producing white crystals. It has a specific gravity of 0.885, and is highly inflammable, giving off copious volumes of its inflammable vapour at the ordinary temperature. It is insoluble in water, but soluble in ether, alcohol, wood spirit, and dissolves iodine, fats, essential oils, resins, rubber, &c. The vapour of benzene on being breathed produces a quickening of the pulse and respiration, and afterwards stupefaction.

Uses.—As a solvent for indiarubber, oils, fats, resins, &c.: manufacture of nitrobenzol and aniline dyes; for increasing the illuminating power of gas.

TOLUENE.

Synonyms.—*Toluol*, *Methylbenzene*, C_7H_8.

Source.—Obtained by subjecting crude benzol to fractional distillation.

Characters. — Pure toluene, or toluol, is a colourless, refractive, and mobile liquid. It boils at 230° F., its vapour being very inflammable, and burns with a bright but very smoky flame. Its specific gravity is 0.872. It does not freeze at 20° C. It has a somewhat similar smell to benzene, of which it is a homologue, but it is not so dangerous to handle. It is insoluble in water, but is soluble in alcohol, ether, bisulphide of carbon, and dissolves oils and fats, sulphur, phosphorus, iodine, &c. Fuming nitric acid converts it into nitro-toluene.

Uses.—As a solvent for rubber goods, oils, fats, resins, &c.; for enriching gas.

SOLVENT AND BURNING NAPHTHA.

Synonym.—*Coal-Tar Naphtha.*

Source.—Those products are prepared from the fraction of distillates produced between 285° and 340° F. in the tar distillation. The fraction is subjected to steam distillation at 300° F. until about 90 per cent. of the liquid has been condensed; this is called solvent naphtha, and the fraction obtained by further distillation is termed burning naphtha.

Characters.—These are brown, mobile, and more or less fluorescent liquids, possessing a disagreeable tarry smell. They are highly inflammable, and consist principally of the benzenoid and paraffin hydrocarbons, with specific gravities ranging from .875 to .887.

Uses.—Solvent naphtha is very extensively employed as a solvent for indiarubber in the fabrication of waterproof materials, and for washing anthracene. It yields 90 per cent. of distillates below 320° F., and has a specific gravity of .872. Burning naphtha is used in special lamps without wicks for lighting up factories, earthworks, stalls, booths, and shows, &c., in fairs and markets. It has a specific gravity from .880 to .887, and 90 per cent. distils below 340° F.

Carburetting naphtha is a name applied to the fraction distilling below 300° F. from crude naphtha, and having a specific gravity ranging from .850 to .870.

Commercial Descriptions of Coal Tar Benzols and Naphthas.

According to Lunge, the usual descriptions of the products from light tar oils yield the following percentages by volume on subjecting them to distillation :—

Commercial Products.	Initial Boiling Point ° F.	Percentages distilled at ° F.									
		190	200	212	230	248	266	280	300	320	340
[1] 90 per cent. benzol -	180	30	65	90	...	...	...	...	...	...	...
[2] 50 per cent. benzol -	190	...	13	54	74	90	...	...	...	...	...
Toluol -	212	...	...	...	56	90	...	...	...	...	...
Carburetting naphtha -	226	...	...	...	1	35	71	84	97	...	...
Solvent naphtha -	230	...	...	...	...	17	57	71	90	...	...
Burning naphtha -	280	...	...	...	...	...	...	...	30	71.5	89

(1) By *90 per cent. benzol* is meant that 90 per cent. by volume may be distilled from it before the temperature rises above 212° F.

(2) By *50 per cent. benzol*, or 50/90 benzol, is meant that 50 per cent. by volume distils before the temperature gets beyond 212° F., and that 40 per cent. more (making 90 altogether) below 248° F. This product distils wholly below 267° F.

CARBOLIC ACID.

Synonyms.—*Phenol*, *Phenic Acid*, C_6H_5HO.

Source.—This important acid can be procured in a variety of ways, the principal source being from certain fractions obtained in the distillation of coal tar. The water, benzenoid, hydrocarbons, &c., having been distilled from the tar up to a temperature of 300° F., the fraction that distils between this and 400° F., and known as *middle oil*, contains the carbolic acid. After allowing to stand some time to separate the greater portion of the naphthalene it contains, the liquid is agitated with caustic soda solution of sp. gr. 1.34 in a cylinder, and allowed to separate. The upper layer contains neutral oils, and the aqueous solution contains the carbolic acid in combination with soda. After separation, the aqueous solution is allowed to stand to deposit impurities, after which the clear solution is fractionally precipitated with dilute sulphuric acid. Tarry matters first separate, then homologues of carbolic acid, then carbolic acid itself.

Characters.—Pure carbolic acid or phenol is a white substance, crystallising in long rhombic needles, melting at 108° F., and boiling at 360° F. Its molecular weight is 94. A few drops of water suffice to liquefy a large quantity of phenol, the specific gravity of liquid phenol being 1.056 at 115° F. It possesses a characteristic tarry smell, and a burning caustic taste. Its solubility in water is 1 in 15, which, however, increases with the temperature, so that at 183° F. it is miscible in all proportions. Pure phenol remains colourless when exposed to light and air; but if impure, will turn red or brown and deliquesces. It is a violent poison, a few drops of the strong acid having been sufficient to cause death. It has a powerful caustic action upon the skin, and coagulates albumen and gelatinous substances.

Uses.—Carbolic acid, owing to its remarkable property of coagulating albuminous substances, is one of the most powerful disinfectants and antiseptics known. A dilute solution is extensively used as an antiseptic in medicine and surgery (Lister's dressing), and for destroying parasitic organisms upon plants and animals. It is a constituent of creosote, used in the pickling of timber for railway sleepers, &c., and is largely used in the preparation of carbolic powders, being absorbed by such substances as kieselguhr marl, infusorial earth, sawdust, &c. M'Dougall's powder is a mixture of carbolate of lime and sulphite of magnesia. It is used in the manufacture of certain soaps and salicylic acid, durin azo colours, &c. Carbolic acid is not in itself an explosive, but is used in the preparation of picric acid (*nitro-phenol*) powders.

NAPHTHALENE.

Synonyms.—*Naphthalin*, $C_{10}H_8$.

Source.—This hydrocarbon may be prepared by passing the vapours of various organic substances through red-hot tubes. It is principally obtained from coal tar, in which it exists to the extent of from 5 to 10 per cent., and occurs principally in the middle oil, which distils between 170° and 230°, and in the creosote oils distilling between 230° and 270°, from which it is deposited on cooling the liquid, after which it is filtered, pressed, and sublimed.

Characters.—Naphthalene produced by the cooling of its saturated solutions, or by sublimation, is a silvery white body, crystallising in rhombic plates. It has an agreeable and characteristic odour, and is somewhat volatile at the ordinary temperature. It melts at 79° C. to a clear liquid, and boils at 217° C., and is completely volatile in a current of steam. It is inflammable, and burns with a brilliant but smoky flame. It has a specific gravity of 1.158. It is practically insoluble in water, alkalies, and dilute acids. It is soluble in alcohol, ether, benzol, bisulphide of carbon, volatile oils, &c. Crude naphthalene, or "naphthalene salts," is an impure variety possessing a very objectionable odour, and contains various oils from tar, from which it can be freed by pressure and sublimation.

Uses.—As a means of increasing the illuminating power of coal gas. This is the substance used for the "*albo-carbon light.*" For the manufacture of artificial colours, such as Manchester yellow (drinitronaphthol), Magdala red (naphthalene red), azo colours. Naphthalene has considerable antiseptic and disinfectant qualities, and is used as an insecticide and vermicide. In combination with camphor, and certain preparations of "sanitas," it is used in the form of blocks for the disinfection of urinal pans, &c.

CREOSOTE.

Synonyms.—*Creosote Oils, Heavy Oil, Dead Oil.*

Source.—This is the fraction of distillate obtained from coal tar between 230° and 270° C., and generally yields from 15 to 23 per cent.

Characters.—The composition of coal tar creosote oils is very complex, and contains numerous liquid and solid substances, such as naphthalene, anthracene, phenanthrene, diphenyl, carbolic and cresylic acids, and various neutral oils. Its specific gravity ranges from 1.03 to 1.065. Creosote has a greenish yellow colour, and is fluorescent. It has a smoky taste, and acts upon the skin as a smarting astringent, owing to the phenol acids it contains. The percentage of "tar acids" present varies from 3 to 24 per cent., depending upon the temperature of the coal distillation, and the quality of coal used. On distilling creosote up to 600° F., the amount condensed varies from 60 to 90 per cent. On cooling the liquid, considerable proportions of the solid naphthaloid hydrocarbons are deposited, which however usually redissolve on heating up to 100° F. It is inflammable, and burns with a smoky flame.

Uses.—The principal application of creosote is for preserving timber, such as railway sleepers, &c., and for this purpose it should have certain physical and chemical properties. The following specification, drawn up by the late Dr Tidy, will give a good idea of the nature of creosote best suited for the purpose:—

"(1.) That the creosote shall be completely liquid at a temperature of 100° F., no deposit afterwards taking place until the oil registers a temperature of 95° F. (2.) That the creosote shall contain 25 per cent. of constituents that do not distil over at a temperature of 600° F. (3.) That it should yield 8 per cent. of tar acids. (4.) That it should contain no admixture of bone oil, shale oil, or any substance not obtained from the distillation of coal tar, and that the first 25 per cent. of the distillate shall have a specific gravity greater than that of water."

Creosote oil is used as a liquid fuel, and for lighting up works, harbours, railways, &c., and also put through processes for the recovery of the naphthalene and carbolic acid it contains. It is a good disinfectant for rough purposes, such as drains, urinals, putrefractive rubbish, &c.

ANTHRACENE.

Synonym.—$C_{14}H_{10}$.

Source.—Obtained from the fraction of tar distilling above 270° C., known as *anthracene oil*, and which constitutes about 16 per cent. of the tar. On cooling, the liquid anthracene and several other solid hydrocarbons are deposited. This deposit is freed from the liquids by filtration and pressure, and is sold as rough anthracene, or is purified by washing with coal tar naphtha, and further filtered and pressed. The average yield of pure anthracene is about 0.8 per cent on the tar used.

Characters.—Pure anthracene crystallises in colourless shining scales, and has a violet fluorescence. It melts at 415° F., and distils practically without decomposition at about 570° F. It is practically insoluble in water, and partially soluble in dilute acids or alkalies, alcohol, benzol, bisulphide of carbon, and ether. It is inflammable, and burns with a smoky flame. Rough anthracene is a brownish green friable mass, and contains a number of impurities, such as naphthalene, methyl-naphthalene, diphenyl, phenanthrene, pyrene, retene, &c., together with various unknown oils of high boiling point.

Uses. — The principal use of anthracene is for the manufacture of alizarin. The green oil expressed from crude anthracene, and which has a very high boiling point, is now extensively used as a liquid fuel for raising steam in stationary and locomotive boilers.

(B.) CRUDE PETROLEUM AND ITS PRODUCTS.

CRUDE PETROLEUM.

Synonyms.—*Mineral Oil, Rock Oil, Liquid Bitumen.*

Source.—Petroleum is a natural occurring oil, and is found in subterranean cavities at various depths in a great many parts of the globe, and is not confined to any special geological formation, the principal source of this important body being the Pennsylvanian field in the United States and Canada, and considerable quantities are obtained from Baku on the Caspian Sea and other localities of the Caucasus, South Russia. Burmah, Galicia, Hanover, also furnish quantities of petroleum, and Algeria promises to be a source of the oil.

Characters.—Crude petroleum, as it is naturally found, varies considerably with regard to its composition and consistency, and may be obtained from a thin, highly inflammable, oily liquid, to a solid substance boiling at so high a temperature as 420° C. Petroleum is a most complex substance, and contains a great number of hydrocarbons, gaseous, liquid, and solid, being principally of the paraffin series. It varies in colour from a light straw colour to brownish black, and generally has a disagreeable odour. In specific gravity it varies from .78 to .97. Some varieties give off inflammable vapours at the ordinary temperature. Its elementary composition averages hydrogen 15 and carbon 85. The products obtained from the distillation and refining of crude petroleum consists of cymogene, rhigolene, gasolene, benzoline or petroleum spirit, naphtha, kerosene, pyronaphtha, lubricating oil, cylinder oil, vaselene, residuum.

The following table shows the number of gallons of various products obtained from 100 gallons of crude Russian petroleum by V. I. Ragonie & Co. :—

	Sp. Gr.	Gallons.
Benzine	·725	1
Gasolene	·775	3
Kerosene	.822	27
Pyronaphtha	.858	12
Lubricating oil	.900	27
Cylinder oil	·915	5
Vaselene	·925	1
Residuum and loss	...	24
		100

Crude American petroleum on distillation yields from 12 to 15 per cent. of naphtha, 9 to 12 per cent. of benzine, and 60 per cent. of burning oil.

Uses.—The principal use is for the production of its valuable constituents, and for liquid fuel and lubrication.

The following table shows the specific gravity and products obtained from American petroleum of 0.800 specific gravity:—

Product.	Specific Gravity.	Percentage.
Cymogene and rhigolene	.590 to .620	Very small
Gasolene	.636 to .657	1.00 to 1.5
"C" naphtha (benzine naphtha)	.700	10
"B" naphtha	.714 to .718	2.5
"A" naphtha (benzine)	.725 to .737	2.0 to 2.5
Kerosene or burning oil	.802	50 to 55
Lubricating oil	.875	17.5
Paraffin wax	...	2
Coke, gas, and loss	...	8 to 10

The following table* shows the specific gravity and yields of commercial products from crude petroleum obtained from various localities :—

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* Redwood (Jour. Soc. Arts, XXXIV. 823, 878).

Locality.	Specific Gravity.	Yield of Commercial Products.			
		Naphtha.	Burning Oil.		Lubricating Oil.
		Per cent.	Per cent.	Sp. Gr.	Per cent.
1. Persia - - -	.777	1.4	87.5	...	...
2. East India - -	.821	3.6	62.5	.800	32.0
3. Burmah, mud volcano, Kyouk Phyou - -	.818	none	55.7	.800	31.3
4. Burmah, native pits, Mimbyin	.866	none	15.1	.810	65.9
5. Burmah, Western Barangah -	.888	none	7.2	.815	89.3
6. Burmah, Eastern Barangah -	.835	2.5	66.1	.810	27.3
7. Assam - -	.933	none	none	...	94.2
8. India - - -	.935	none	20.0	.805	60.0
9. Russia - -	.936	20.0	40.0	...	37.5
10. Russia - -	.942	none	none	...	90.0
11. Hanover - -	.843	10.0	60.0	.812	27.5
12. South America -	.852	none	50.0	.808	45.0
13. South America -	.900	none	none	...	91.5
14. New Zealand -	.828	none	60.0	.808	38.0
15. Italy, near Milan	.787	45.0	45.0	.806	5.0
16. United States, Wyoming -	.910	2.5	27.5	...	57.5
17. United States, Wyoming -	.945	none	10.0	...	72.5
18. Scotch shale oil -	.870	6	36	.810	18.0

It may be here added that the products obtained from the distillation of tar from shale are very similar to those obtained from crude petroleum.

MINERAL NAPHTHA.

Synonyms.—*Shale Naphtha, Benzoline, Benzine, Petroleum Spirit, Benzin.*

Source.—This substance is obtained from crude petroleum or shale tar by distillation, and consists of the lightest fractions distilling up to 212° F.

Characters. — Mineral naphtha or benzoline is a thin, colourless, volatile liquid, of peculiar and somewhat pleasant odour, and consists of a number of volatile and highly inflammable hydrocarbons. It has a specific gravity of about 0.700. It gives off inflammable vapour at the ordinary temperature. It is insoluble in water, and dissolves in about 6 parts by weight of rectified spirit. By subjecting this body to fractional distillation a number of products are obtained, of which the following is a list showing their characters and uses :—

	Commercial Name.	Specific Gravity.	Characters.	Uses.
	Cymogene -	.590	Consists principally of butane, C_4H_{10}, highly inflammable and explosive when mixed with air. It is condensed by artificial pressure	It is sometimes employed in the production of low temperatures in refrigerating machines.
Petroleum ether	Rhigolene -	.625 to .631	A highly volatile and inflammable liquid consisting mainly of pentane, C_5H_{12}	As a local anæsthetic, for gas engines, and for Harcourt's standard for estimating the illuminating power of coal gas.
	Gasolene -	.635 to .665	Colourless, highly inflammable liquid, consisting mainly of hexane, C_6H_{14}.	For increasing the candle power of coal gas, and for carburetting air.
Petroleum spirit or benzoline	C. naphtha Benzine naphtha	.680 to .700	Colourless liquid, highly inflammable, consisting chiefly of the higher members of the paraffin hydrocarbons	Used for burning in "benzoline" or sponge lamps, and as a solvent of oils and fats, and is also used in certain varnishes.
	B. naphtha	.714 to .718		
	A. naphtha Benzine -	.740 to .745	Do.	As a turpentine substitute, and for cleaning printers' types, and for burning.

Petroleum spirit dissolves all the principal oils and resins.

Uses.--For burning in benzoline lamps; as a solvent for various organic bodies; for carburetting gas; and for use as a turpentine substitute in varnishes and paints.

MINERAL BURNING OIL.

Synonyms.—*Kerosene*, *Photogene*, *Paraffin Oil*, *Refined Petroleum*, *Water White Oil*, *Crystal Oil.* The following are also fancy names applied to various mineral oils used for burning, many of which are identical in quality:—*Petroline*, *Puroline*, *Septoline*, *Liquid Gas*, *Astral Oil*, *Beacon Oil*, *Aurora Oil*, *Safety Gas*, *Solar Oil*, *Pyronaphtha*, *Belmontine Oil*, *Mineral Sperm Oil*, *Mineral Colza Oil*, *Mineral Seal Oil*, *Cazeline Oil*, *Colzarine.*

Source.—Obtained in the fractional distillation of crude petroleum and shale oil.

Characters.—Kerosene may be a perfectly colourless or slightly yellow liquid containing various hydrocarbons, and generally has a blue fluorescence, though not in all cases. It has a characteristic odour and taste. It is insoluble in water, slightly soluble in alcohol, but soluble in all proportions in ether, benzol, chloroform, petroleum spirit, volatile and fixed oils (except castor oil). It softens rubber, and is a solvent for waxes, camphor, certain resins, sulphur, iodine, &c. The specific gravity of kerosene varies when obtained from different sources. The specific gravity of American kerosene is generally 0.803; Russian kerosene, 0.822; and the "paraffin" oil from shale, 0.800. The temperature at which the vapour of mineral burning oils or kerosene become ignited on application of a flame should not be below 73° F., unless otherwise stipulated and sanctioned by the discretionary powers vested in local authorities. The storage and sale of burning oil is restricted by the Petroleum Act of 1871 (34 & 35 Vict. cap. 105) and the Amended Act of 1879 (42 & 43 Vict. cap. 47). Petroleum is defined by the Act to "include all such rock oils, rangoon oils, oils made from petroleum, coal, schist, shale, peat, or other bituminous substances; any products of petroleum or any of the above-mentioned oils, which, when tested as directed, give off inflammable vapour at a temperature less than 73° F." The minimum flash point of the 1871 Act was 100° F., and with the introduction of Abel's new standard flash point apparatus the minimum flash point was fixed at 73° F. in the Amended Act of 1879. (For the description of the Act and flash point apparatus, see page 75.) Owing to the number of fatal lamp accidents constantly occurring, it is thought by many that the present standard ought to be raised considerably. No doubt oils of higher flash point would be safer for the general public use, especially for the poorer classes, who out of necessity have to use cheap and frail lamps, which so quickly get out of order, and thus enhancing the chances of inflammation and explosion. See also page 255.

Uses.—Enormous quantities of kerosene or refined petroleum are used for lighting purposes in all parts of the world. It is also used in considerable quantity as a liquid fuel and for the production of oil gas for lighting railway carriages. It is a constituent of various cleansing compositions, and is used for increasing the growth of hair, and also as a germicide and antiparasite.

The Storage of Petroleum.

Owing to the high degree of inflammability of petroleum oils, it is of importance that great care should be exercised in their storage. The following are some of the best means of safely storing petroleum :—

(1.) The oil to be kept in metallic tanks, sunk some distance into the ground, from which quantities can be drawn as required with the aid of a hand pump.

(2.) If the ordinary wooden barrels be desired to be kept intact, they should be kept in isolated warehouses of one storey only, built of uninflammable materials.

(3.) Weights are attached to the ordinary barrels, which are then sunk in water.

(4.) A convenient mode of storing inflammable oils is to place a vessel similar to a gas-holder, mouth downwards, into a large tank filled with water, in which the oil can thus be stored over the water, from which quantities can be drawn as required.

Apropos of the petroleum storage in towns, the Fire Brigade Sub-Committee recently reported to the Birmingham Corporation as follows:—"The Petroleum Acts 1871 and 1879 only apply to a product or any other spirit giving off an inflammable vapour at less than 73° F. There are eighty persons licensed to keep the product of petroleum known as benzoline, all of which is kept in compliance with the above Acts. Any quantity of the common petroleum or lamp oil can be stored, provided it is only one degree above the specified flashing point above mentioned. The spirit of petroleum is very volatile; so much so, that a light applied within a short distance whilst drawing off the same will cause it to explode. We have caused inquiries to be made, and find that there are, in addition to the large stores, over six hundred premises in the city where common petroleum is sold. Of these ninety-seven were visited, and about 13,000 gallons found on the premises. In very many instances the premises were unsuited to the keeping of such an inflammable oil, as most of them were also occupied as dwellings, with six, eight, or ten in family. The risk to life in these cases is very serious, as the following cases will show.

"Case A. keeps 2 gallons of common petroleum in the shop and 160 gallons in a shed, one side of which forms a part of a baker's oven. B. keeps 120 gallons of common petroleum under the staircase to the living rooms. It is a very small shop, and eight persons reside on the premises. In some instances we find common petroleum sold by occupiers of private houses. The quantity kept did not exceed 5 gallons, but the risk in these cases is very serious, owing to the oils being kept in cupboards, &c., close to the fireplaces. In one instance, a can of oil was by the side of the fireplace, where a footstool would usually be kept, and was poured out by a little girl into cups to be sold. As regards large stores, one dealer is licensed to keep 10,000 gallons of benzoline in one store, and permitted to keep in an adjoining store 33,000 gallons of common petroleum. The Committee wish Parliament to grant local authorities further powers to regulate the storage of petroleum."

Precautions as to the Management of Petroleum Tank Steamships.

While accidents have occurred with petroleum-laden vessels at sea, due to leakage, carelessness with the use of lights, &c., there can be no doubt that the chief risk of explosion or fire with such inflammable cargoes is when the vessel is in port, loading or discharging; and during these operations no naked lights should be permitted on board, and smoking should be strenuously prohibited. Lights required anywhere near the oil during the operations of loading or discharging should be provided by means of electric glow lamps. Many serious explosions have taken place on board petroleum ships after the cargo has been discharged, due to naked lights being introduced into the hold during inspections or repairs; and even if safety lamps were used, there would still be the risk of any petroleum vapour, which might be present in certain proportions in the atmosphere, exploding when repairs were required involving the use of red-hot rivets.

In the report of the Inspectors of the Board of Trade on the explosion which took place at Newport, in May 1891, on board the petroleum vessel "Tancarville," it was suggested that "when repairs require to be carried out in a vessel which has been carrying petroleum, there should be a formal handing over of the vessel to those by whom the repairs are to be undertaken, and a certificate that the tanks and all dangerous spaces have, so far as practicable, been adequately cleansed and ventilated, and rendered free from risk of explosion or fire. If from any cause a complete certificate of this sort cannot be given, then it should be clearly notified which tanks or spaces have not been cleansed, and are still dangerous."

Thanks to the researches of Mr Boverton Redwood, F.R.S.E., and Professor Clowes, and to the system of dealing with discharged petroleum vessels now adopted by the Board of Trade, the risk of explosion of petroleum vapours and air is reduced to a minimum. By the Redwood system of testing, a certificate is now given as to the freedom of the air from inflammable vapours in discharged petroleum vessels before they are handed over for repairs or reloading, and this method of testing is now carried out on all petroleum tank steamships that enter British ports. The system of testing is unique, sensitive, and reliable. The following are details of the apparatus and instructions as to its use.

Instructions for the Use of the Redwood Apparatus for Detecting Inflammable Vapours on Board Petroleum Tank Steamships.*

The complete appliances are shown on page 74. They consist of the lamp A, the reservoir of compressed hydrogen B, and the sampling vessel C, in which the sample of air for examination is collected. The lamp is shown in section in Fig. 2. A is the hydrogen inlet tube with the regulating valve B, and C is the hydrogen jet. D is the inlet tube, for the sample of atmosphere to be tested. The bore of this tube is greatly contracted, and immediately above the point at which this tube enters the base of the lamp is an arrangement of baffles, surmounted by three discs of wire gauze of at least 28 wires per lineal inch, or not less than 784 openings per square inch, the flow of the gaseous mixture to the flame being thus regulated, and passage of flame into the collecting vessel being prevented. The chimney E fits air-tight at the base, but is capable of vertical movement on an inner tube, the front of which is removed. The chimney is partly of metal and partly of glass, the metallic portion being blackened inside, and on the glass window lines corresponding with various heights of flame caps may be marked. The top of the hydrogen jet tube is 10 millimetres (0.4 inch) below the bottom of the window. Attached to the base of the lamp is a telescopic support for a cloth, which envelops the head of the observer and excludes light when the testing apparatus is used in an undarkened room. The construction of the collecting vessel is shown in section in Fig. 3. A is the compression pump, which is furnished with a metallic spring piston, fitting the pump cylinder without the use of leather or other material, and lubricated with plumbago. Surrounding the pump is an annular space, in which the sample of atmosphere is stored. B is a collar to which may be attached a flexible suction tube of any desired length. C is a cock, to which is attached a copper tube conveying the sample to the test lamp. The bore of this cock is very much reduced. D is a pressure gauge, and

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* *Vide* Proc. Inst. Civil Engineers, vol. cxvi., part ii.

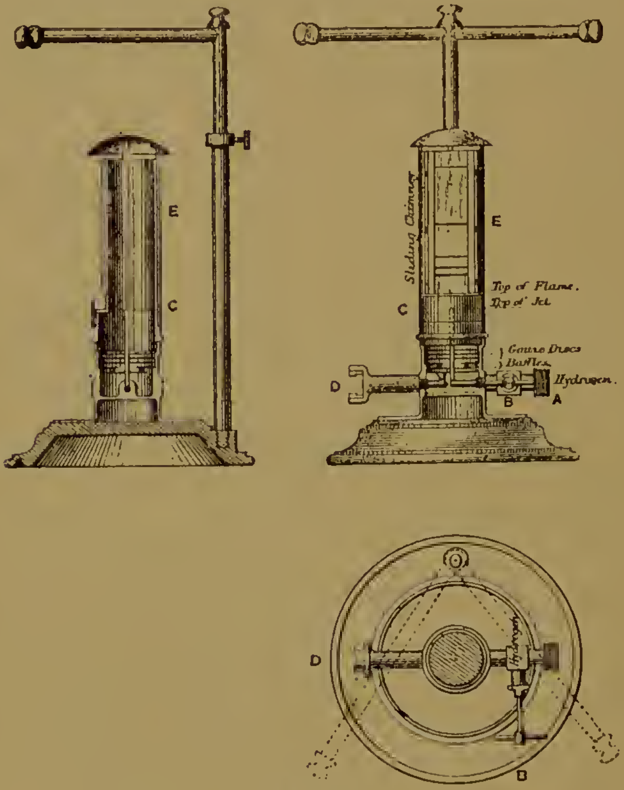

FIG. 2.

E a spring valve lifting at 30 lbs. pressure. F F are hinged brackets, on which the feet of the operator are placed while the pump is being worked. G is a handle, by which the cylinder can be conveniently carried. The capacity of the pump is 14.84 cubic inches, and of the annular space 169.14 cubic inches, thirty double strokes of the pump being required to charge the vessel to a pressure of 30 lbs. per square inch, when it will contain $\frac{1}{3}$ cubic foot of the atmosphere sampled.

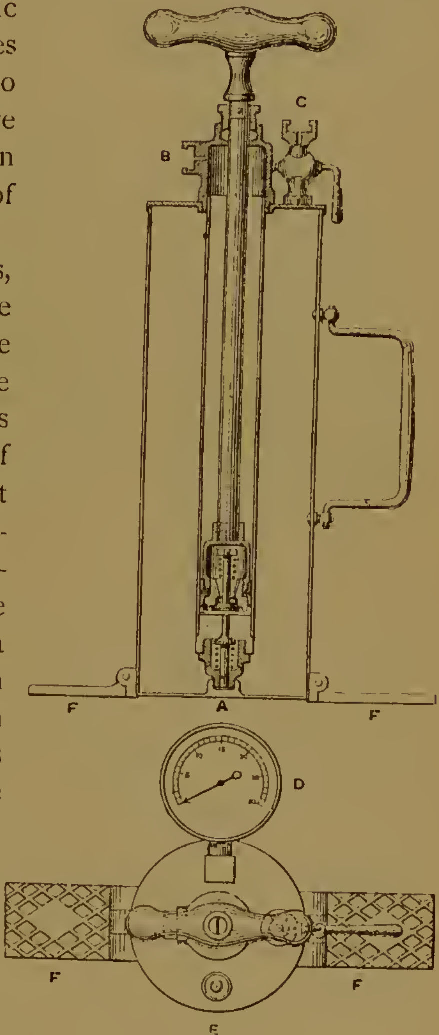

FIG. 3.

In the use of the apparatus, the first step is to connect the hydrogen cylinder with the lamp, taking care that the unions are screwed up gas tight. The sliding chimney of the lamp being raised about half way, the gas is then cautiously turned on at the cylinder, the regulating valve on the lamp being left open, and a light is applied to the hydrogen jet. The valve on the hydrogen cylinder is then adjusted so as to give a flame rather more than 10 millimetres (0.4 inch) in length, and the lamp chimney pushed down until there is an opening of only about $\frac{1}{4}$ inch in height at the bottom. This opening is left for the supply of air to the hydrogen flame during the few minutes occupied in the warming of the chimney. As soon as the moisture which is at first condensed upon the cold glass has evaporated, the lamp is ready for use, and assuming the collecting vessel to have been already charged with the sample to be tested, and connected with the lamp, all that remains is for the observer to completely close the sliding chimney of the lamp, adjust the hydrogen flame by means of the regulating valve on the lamp, so that the tip of the flame is

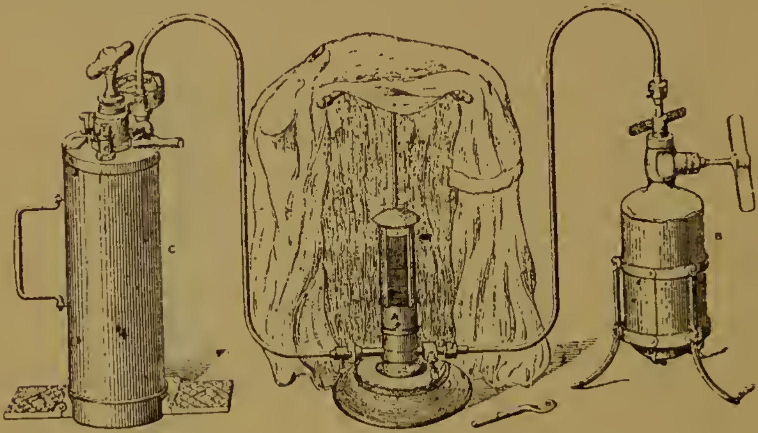

FIG. 4.

only just hidden when the eye of the observer is on a level with the bottom of the window, place his head under a cloth, such as used by photographers, so as to exclude light, and as soon as his eyes have become sufficiently sensitive, turn on the tap of the collecting cylinder, and carefully observe what takes place in the lamp chimney. The tap may at once be turned on fully, as the contraction of the outlet and inlet orifices, already referred to, prevents the sudden rushing out of the contents of the cylinder, and the sample will be gradually delivered into the test lamp during a period of more than two minutes, which is ample time for noting the effect. The rate of delivery is, of course, a gradually diminishing one, but this is not found to be attended with any inconvenience, the conditions being the same in each experiment. In this way a proportion of vapour, considerably below that which is required even for the production of an inflammable mixture, and still lower than that which is needed to give an explosive atmosphere, may be detected by the formation of a flame cap of greyish-blue colour, which, though faint, is nevertheless easily seen, especially after a little practice. With an increase in the quantity of vapour, the flame cap first becomes much better defined, though it is not greatly augmented in size, and then considerable enlargement of the cap occurs, this condition being arrived at before the atmosphere becomes inflammable.

Text of the Petroleum Act, 1879.

(42 & 43 VICT. c. 47.)

1. This Act may be cited as the Petroleum Act, 1879.

This Act shall be construed as one with the Petroleum Act, 1871, and together with that Act may be cited as the Petroleum Acts, 1871 and 1879.

2. Whereas by the Petroleum Act, 1871, it is enacted that the term "petroleum to which this Act applies" means such of the petroleum defined by that Act as, when tested in manner set forth in Schedule 1 to that Act, gives off an inflammable vapour at a temperature of less than 100° of Fahrenheit's thermometer, and it is expedient to alter the said test: Be it therefore enacted that—

In the Petroleum Act, 1871, the term "petroleum to which this Act applies" shall mean such of the petroleum defined by Section 3 of that Act as, when tested in manner set forth in Schedule 1 to this Act, gives off an inflammable vapour at a temperature of less than 73° of Fahrenheit's thermometer.

Every reference in the Petroleum Act, 1871, to Schedule 1 to that Act shall be construed to refer to Schedule 1 to this Act.

3. A model of the apparatus for testing petroleum, as described in Schedule 1 to this Act, shall be deposited with the Board of Trade, and the Board of Trade shall, on payment of such fee, not exceeding five shillings, as they from time to time prescribe, cause to be compared with such model and verified every apparatus constructed in accordance with Schedule 1 to this Act which is submitted to them for the purpose, and if the same is found correct shall stamp the same with a

mark approved of by the Board and notified in the London Gazette.

An apparatus for testing petroleum purporting to be stamped with the said mark shall, until the contrary is proved, be deemed to have been verified by the Board of Trade.

All fees under this section shall be paid into the Exchequer.

4. The Petroleum Act, 1871, shall continue in force until otherwise directed by Parliament.

5. This Act shall come into operation on the 31st day of December 1879, which day is in this Act referred to as the commencement of this Act.

6. The Petroleum Act, 1871, shall be repealed after the commencement of this Act to the extent in the third column of the Second Schedule to this Act mentioned.

Provided that any sample of petroleum taken before the commencement of this Act shall be tested in manner set forth in Schedule 1 to the Petroleum Act, 1871, and any offence committed before the commencement of this Act shall be prosecuted, and any investigation, legal proceeding, or remedy in relation to such offence, or to any act done before the commencement of this Act, shall be instituted, carried on, and have effect as if the provisions of this Act, other than those continuing the Petroleum Act, 1871, had not been passed.

FIRST SCHEDULE.—Mode of testing Petroleum so as to ascertain the Temperature at which it will give off Inflammable Vapour. Specification of the Test Apparatus.

SECOND SCHEDULE.—Act repealed.

Year and Chapter.	Title.	Extent of Repeal.
34 & 35 Vict. c. 105.	The Petroleum Act, 1871.	Section three, from "and the term petroleum to which this Act applies" inclusive to the end of the section. Section eighteen.

The following is a sketch of the apparatus and *modus operandi* of the process for the determination of the flashing points of light mineral oils as devised by Sir Frederick Abel, and set forth in Schedule 1 of the Petroleum Act of 1879:—

Specification of the Test Apparatus (Fig. 5).—The oil cup consists of a cylindrical vessel 2 inches in diameter and 2$\frac{2}{10}$ inches in height (internal), with outward projecting rim $\frac{5}{10}$ inch wide, $\frac{3}{8}$ inch from the top, and 1$\frac{7}{8}$ inch from the bottom of the cup. It is made of gun-metal or brass (17 B.W.G.) tinned inside. A bracket consisting of a short stout piece of wire bent upwards, and terminating in a point, is fixed to the inside of the cup to serve as a gauge. The distance of the point from the bottom of the cup is 1$\frac{1}{2}$ inch. The cup is provided with a close-fitting overlapping cover made of brass (22 B.W.G.), which holds the thermometer and test lamp. The latter is suspended from two supports from the side by means of trunnions, upon which it may be made to oscillate; it is provided with a spout, the mouth of which is $\frac{1}{16}$ inch in diameter. The socket which is to hold the thermometer is fixed at such an angle, and its length so adjusted, that the bulb of the thermometer when inserted to its full depth shall be 1$\frac{1}{2}$ inch below the centre of the lid.

The cover is provided with three square holes, one in the centre $\frac{5}{10}$ inch × $\frac{4}{10}$ inch, and two smaller ones $\frac{3}{10}$ inch × $\frac{2}{10}$ inch close to the sides and opposite each other. These three holes may be closed and uncovered by means of a slide moving in grooves, and having perforations corresponding to those on the lid.

In moving the slide so as to uncover the holes, the oscillating lamp is caught by a pin fixed in the slide and tilted in such a way as to bring the end of the spout just below the surface of the lid. Upon the slide being pushed back so as to cover the holes, the lamp returns to its original position.

Upon the cover, in front of and in line with the mouth of the lamp, is fixed a white bead, the dimensions of which represent the size of the test flame to be used.

The bath or heated vessel (see Fig. 5) consists of two flatbottomed copper cylinders (24 B.W.G.), an inner one of 3 inches in diameter and $2\frac{1}{2}$ inches in height, and an outer one $5\frac{1}{2}$ inches in diameter and $5\frac{3}{4}$ inches in height; they are soldered to a circular copper plate (20 B.W.G.) perforated in the centre, which forms the top of the bath in such a manner as to enclose the space between the two cylinders, but leaving access to the inner cylinder. The top of the bath projects both outwards and inwards about $\frac{3}{8}$ inch,—that is, its diameter is about $\frac{6}{8}$ inch greater than that of the body of the bath, while the diameter of the circular opening in the centre is about the same amount less than that of the inner copper cylinder. To the inner projection of the top is fastened, by six small screws, a flat ring of ebonite, the screws being sunk below the surface of the ebonite

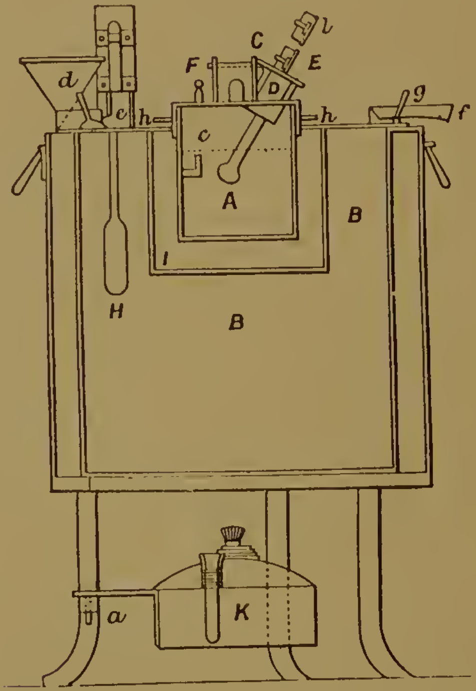

Fig. 5.— Sir F. Abel's Flash-point Apparatus.

B Water bath.
A Oil cup.
C Gauge.

E Thermometer.
G Oscillating lamp.
I Air chamber.
H Thermometer.

K Spirit lamp
F Flame gauge.
d Funnel.

to avoid metallic contact between the bath and the oil cup. The exact distance between the sides and bottom of the bath and of the oil lamp is ½ inch. A split socket, similar to that on the cover of the oil cup, but set at a right angle, allows a thermometer to be inserted into the space between the two cylinders. The bath is further provided with a funnel, an overflow pipe, and two loop handles. The bath rests upon a cast-iron tripod stand, to the ring of which is attached a copper cylinder or jacket (24 B.W.G.), flanged at the top, and of such dimensions that the bath while firmly resting on the iron ring just touches with its projecting top the inward turned flange. The diameter of this outer jacket is 6½ inches. One of the three legs of the stand serves as a support for the spirit lamp, attached to it by means of a small swing bracket. The distance of the wick-holder from the bottom of the bath is 1 inch. Two thermometers are provided with the apparatus, the one for ascertaining the temperature of the bath, the other for determining the flashing point.

The thermometer for ascertaining the temperature of the water has a long bulb, and a space at the top; its range is from about 90° to 190° F. The scale (in degrees of Fahrenheit) is marked on an ivory back, fastened to the tube in the usual way. It is fitted with a metal collar fitting the socket, and a part of the tube below the scale should have a length of about 3½ inches, measured from the lower end of the scale to the end of the bulb The thermometer for ascertaining the temperature of the oil is fitted with collar and ivory scale in a similar manner to the one described. It has a round bulb, a space at the top, and ranges from about 50° to 150° F. It measures from end of ivory back to bulb 2¼ inches.

Note.—A model apparatus is deposited at the Weights and Measures Department of the Board of Trade.

Directions for Applying the Flashing Test.—(1.) The test apparatus is to be placed for use in a position where it is not exposed to currents of air or draught.

(2.) The heating vessel or water bath is filled by pouring water into the funnel until it begins to flow out at the spout of the vessel. The temperature of the water at the commencement of the test is to be about 130° F., and this is attained in the first instance either by mixing hot and cold water in the bath, or in a vessel from which the bath is filled until the thermometer which is provided for testing the temperature of the water gives the proper indication; or by heating the water with the spirit lamp (which is attached to the stand of the apparatus) until the required temperature is indicated. If the water has been heated too highly, it is easily reduced to 130° F. by pouring in cold water little by little (to replace a portion of the warm water) until the thermometer gives the proper reading. When the test has been completed, this water-bath is again raised to 130° F. by placing the lamp underneath, and the result is readily obtained while the petroleum cup is being emptied, cooled, and refilled with a fresh sample to be tested. The lamp is then turned on its swivel from under the apparatus, and the next test is proceeded with.

(3.) The test lamp is prepared for use by fitting it with a piece of flat-plaited candle wick, and filling it with colza or rape oil to the lower edge of the opening of the spout or wick tube. The lamp is trimmed so that when lighted it gives a flame of about 0.15 of an inch in diameter, and this size of flame, which is represented by the projecting white bead on the cover of the oil cup, is readily maintained by simple manipulation from time to time with a small wire trimmer. When gas is available it may be conveniently used in place of the little oil lamp, and for this purpose a test flame arrangement for use with gas may be substituted for the lamp.

(4.) The bath having been raised to the proper temperature, the oil to be tested is introduced into the petroleum cup, being poured in slowly until the level of the liquid just reaches the point of the gauge which is fixed in the cup. In warm weather the temperature of the room in which the samples to be tested have been kept should be observed in the first instance, and if it exceeds 65° F. the samples to be tested should be cooled down (to about 60° F.) by immersing the bottles containing them in cold water, or by any other convenient method. The lid of the cup with the slide closed is then put on, and the cup is placed into the bath or heating vessel. The thermometer in the lid of the cup has been adjusted so as to have its bulb just immersed in the liquid, and its position is not under any circumstances to be altered. When the cup has been placed in the proper position, the scale of the thermometer faces the operator.

(5.) The test lamp is then placed in position upon the lid of the cup; the head line or pendulum, which has been fixed in a convenient position in front of the operator, is set in motion; and the rise of the thermometer in the petroleum cup is watched. When the temperature has reached about 60° F., the operation of testing is to be commenced, the test flame being applied once for every rise of 1° F. in the following manner:—

The slide is slowly drawn open while the pendulum performs three oscillations, and is closed during the fourth oscillation.

Note.—If it is desired to employ the test apparatus to determine the flashing points of oils of very low volatility, the mode of proceeding is to be modified as follows:—

The air chamber which surrounds the cup is filled with cold water to a depth of 1½ inches, and the heating vessel or water bath is filled as usual, but also with cold water. The lamp is then placed under the apparatus and kept there during the entire operation. If a very heavy oil is being dealt with, the operation may be commenced with water previously heated to 120° F., instead of with cold water.

MINERAL LUBRICATING OILS.

Synonyms.—*Vacuum Oil*, *Valvoline Globe Oil*, *Ragosine Oil*, *Vulcan Oil*, *Oleonaphtha*, *Hydrocarbon Oil*, and many other fancy names.

Source.—The principal sources of these oils are from crude petroleum, and from the tar obtained from bituminous shale, and are generally obtained from the fraction that distils between the burning oils and paraffin wax or petroleum residuum or *astatki*. The percentage of this distillate varies from 5 to 90 per cent., depending upon the nature of the original crude oil. In some instances the oil can be used for lubrication in its natural state, and in others the more volatile oils are distilled off, and the residue utilised for the purpose, the residue being treated with charcoal and other purifying agents.

Characters.—Mineral or hydrocarbon lubricating oils have a specific gravity ranging from .850 to .925. They vary greatly in body or viscosity. Some are as thin as water, and others are semi-solid at the ordinary temperature. After having undergone chemical treatment, some of the oils are odourless, while others have a strong characteristic smell. They vary in colour from yellow through shades of red brown to black. Some are clear and transparent, and others quite opaque. They vary in flash points from 200° F. to 500° F. The boiling points also vary greatly. They generally exhibit a strong blue or green fluorescence. They are insoluble in water, alcohol, acids, and alkalies, but ether, benzol, and petroleum spirit are miscible in all proportions. Application of heat greatly increases the fluidity of these oils, and cold on the other hand increases the viscosity or body. Some mineral lubricating oils from Baku require so low a temperature as -20° F. before they become congealed, while others are nearly solidified at the ordinary temperature. Bloomless oils distilled from shale generally deposit solid paraffin when exposed to about 18° F.

Uses.—The class of use these oils are put to depends upon the nature of the lubrication required. The lightest or most fluid oils are used for light machinery, such as sewing machines, spindles, clockwork, &c. The intermediate oils for locomotive bearings, tool machines, light axle bearings, &c., and the heavier or thickest oils for cylinders, valves, and heavy bearings.

Mineral oils are sometimes mixed with vegetable or animal oils for lubricating purposes.

Mineral oil is now much used in preference to fatty oils for lubrication, since they have practically no corrosive action upon bearings, &c.

VASELENE.

Synonyms.—*Petroleum Jelly, Soft Paraffin, Vaseline, Vaseline Tallow, Ozokerine, Fossiline, Chrysine, Cosmoline, Saxolene, Geoline, Petrolina, &c.*

Source.—Vaselene is not a distilled product, but during the distillation of crude petroleum the process is arrested after the greater part of the oil has been removed, the residue is treated with sulphuric acid and superheated steam, and then filtered through animal charcoal.

Characters.—Vaselene is colourless, or pale yellow, odourless, tasteless, translucent, fluorescent, semi-solid. The inferior varieties have a dark greenish or brownish colour. It has a melting point ranging from 104° to 122° F., and a specific gravity at 212° F. of from .803 to .855 (water = 1 at 60° F.). It consists principally of the hydrocarbons of the paraffin series, and also a tolerable amount of olefins. It is insoluble in water, and slightly soluble in alcohol. It is soluble in ether, chloroform, benzol, turpentine, and carbon disulphide. It is inflammable at high temperatures.

Uses.—As a lubricant, and as a constituent of various greases. It is extensively used in pharmacy as a protection to wounds and sore parts, and is a desirable base for many ointments. It is also used as a pomade.

PETROLEUM RESIDUUM.

Synonym.—*Astatki.*

Source.—The material is the residue left in the retort after the completion of distillation of crude petroleum.

Characters.—The consistency of this body depends as to what temperature the distillation of the petroleum was arrested.

Some distillers continue the process until the residue is coked, others until a pitch is obtained. The residue produced by the Russian producers, and known as *astatki*, is tolerably fluid at the ordinary temperature. By subjecting this product to distillation, it will yield various qualities of burning oil, lubricating oil, paraffin scale, and pitch. The Baku residue is a black, tarry-looking liquid, with a peculiar odour. The flash point of the residuum varies according to the extent of distillation, but is generally above 300° F. It burns when kindled, with a smoky flame.

Uses.—Is a constituent of railway truck grease, some varieties of which contain 40 to 50 per cent. It is also largely used as a liquid fuel for burning under locomotive and stationary boilers in the localities where produced, and experiments are being made in this country on the Great Eastern Railway to ascertain if it would pay to import it to compete with coal. It is feared, however, that the price is prohibitive.

PARAFFIN WAX.

Synonyms.—*Paraffin*, *Solid Paraffin*.

Source.—Is found native in certain bituminous strata and in the coal measures, and known as *fossil wax*, *hachettin*, *ozokerite*, and exists in shale tar, certain crude petroleums, tar from cannel coal, &c., from which it may be obtained by first distilling off the more volatile oils, and exposing the residue to a low temperature. Paraffin is thus precipitated, and which can be separated from the more liquid paraffins by pressing through bags. This solid is known in commerce as *paraffin scale*, and is subjected to purification before fit for candle-making.

Characters.—Paraffin, when pure, is a white, wax-like, tasteless, and odourless solid hydrocarbon. Its elementary composition is carbon 85 and hydrogen 15, and consists of a number of paraffin and olefin hydrocarbons. When ignited it burns with a bright flame, which is practically smokeless. The specific gravity of this body may vary from .824 to .940, and the melting point, which varies from 89° to 176° F., increases with the gravity. It is insoluble in water and alcohol, but is easily dissolved by ether, petroleum spirit, mineral naphtha, kerosene, and benzol.

Uses.—This important body is produced on a very large scale from shale oil, for the manufacture of composite or paraffin candles, and for which purpose it is generally mixed with from 5 to 15 per cent. of stearic acid to increase its hardness and melting point. Wax matches and tapers also consume much paraffin.

(C.) FIXED OILS AND FATS.

Source.—These are naturally occurring bodies in plants and terrestrial and marine animals. Their extraction from vegetable tissues is brought about by boiling the crushed, oleaginous material with water, or subjecting it to great pressures. In some cases the oil or fat is dissolved out by carbon bisulphide or petroleum spirit, which on distillation leaves the oils as a residuum. They are extracted from animal tissues in a somewhat similar manner.

Characters.—The fixed oils and fats at the ordinary temperature are liquid or solid, greasy or unctuous bodies, possessing odours and tastes characteristic of their origin. They vary in colour from water white or pale yellow through shades of dark yellow, red to dark brown. These bodies do not give off inflammable vapours at the ordinary temperature, and require considerable heat to ignite them, but once they are kindled they burn fiercely, giving off acrid vapours. The specific gravities of the oils and fats vary from .808 to .970. They are thus all lighter than water. They have no fixed boiling point, but when heated to high temperatures, such as 600° F., they decompose, giving rise to various gaseous, liquid, and solid compounds. On being subjected to distillation with superheated steam, they are decomposed into fatty acids and the triatomic alcohol glycerin. They are insoluble in water, difficultly soluble in hot alcohol, but are dissolved readily by ether, benzol, chloroform, bisulphide of carbon, turpentine, naphtha, &c. All the fixed oils and fats are miscible with each other. On exposure to the atmosphere for some time, many of the oils absorb considerable quantities of oxygen, and are thickened owing to the formation of resinous bodies. Such oils are termed *drying oils*, and are extensively used for varnishes, &c., the following being the more important: linseed, walnut, hempseed, and poppyseed oils. Those oils which do not absorb any notable quantity of oxygen from the air are termed *non-drying* oils, and are represented by olive, almond, and rapeseed oils. In chemical constitution all vegetable or animal oils and fats consist of ethers of the various higher fatty acids, and called glycerides or glycyl ethers. On heating with caustic alkalies (potash, soda, lime, or ammonia), the oils and fats are decomposed, the process being termed *saponification*, glycerin is produced, and the fatty acid also formed combines with the alkali forming *soap*, the whole being soluble in alcohol or water, except when lime is used. Most of the oils and fats have some characteristic glyceride predominating. Thus olein, the glyceride of oleic acid, is the principal constituent of olive, almond, and lard oils; *linolein* and *ricinolein*, the glycerides of linoleic and ricinoleic acids, are those characteristic of linseed and castor oils; *palmitin*, the glyceride of palmitic acid, is principally found in palm oil; and *stearin*, the glyceride of stearic acid, is characteristic of beef and mutton fat (tallow).

The following tables in groups give the Sources, Characters, and Uses of the Various Vegetable and Animal Oils, Fats, and Waxes.*

I.—OLIVE OIL GROUP.

VEGETABLE OLEINS, VEGETABLE NON-DRYING OILS.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Solidifying Point ° F.	Uses.
Olive oil - - -	Fruit of *Olea europæa* - -	.914 to .917	39° to 21°	Cooking food, soapmaking, woollen manufacture, turkey-red dyeing.
Almond oil - -	Nuts of *Amygdalis communis*	.914 to .920	14° to 12°	In pharmacy for making emulsions, liniments, ointments, &c.
Peach oil - -	Kernels of *Prunus persica* -	.919 to .923	below -4°	Substitute for almond oil.
Apricot oil - -	Kernels of *P. armeniaca* -	.916 to .920	below -4°	Substitute for almond oil.
Earthnut oil - -	Nuts of *Arachis hypogæa* -	.916 to .920	23°	As a substitute and adulterant for olive, lard, and other oils.
Behen oil - -	Seeds of *Moringa oleifera* -	.912 to .917	about 32°	Extraction of perfumes from flowers, preparation of "Macassar oil."
Tea oil - - -	Seeds of *Camellia oleifera* -	.917	below -4°	Pharmacy.
Rapeseed or colza oil	*Brassica campestris; B. napus;* and allied species	.914 to .916	21° to 14°	Burning in lamps, lubrication, soapmaking, &c.
Chinese cabbage oil -	Seeds of *Brassica sinensis* -	.914	11°	Pharmacy.
Oil of black mustard	Seeds of *Sinapis nigra* -	.916 to .920	-4°	Same of rape oil.
Oil of white mustard	Seeds of *Sinapis alba* - -	.914 to .916	below -4°	Same of rape oil.

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* *Vide* Allen's Comcl. Analysis.

II.—COTTONSEED OIL GROUP. VEGETABLE OILS INTERMEDIATE IN DRYING PROPERTIES BETWEEN THE DRYING AND NON-DRYING OILS.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Solidifying Point ° F.	Uses.
Cottonseed oil	*Gossypium barbadense* and allied species	.922 to .930	40° to 33°	Cooking, butterine, soapmaking, and adulterating other oils.
Cress-seed oil	*Lepidum sativum*	.924	5°	
Grapeseed oil	*Vitis vinifera*	.920	5°	
Sesamé or teel oil	Seeds of *Sesamum orientale* or *indicum*	.921 to .924	40° to 23°	Cooking, pharmacy, butterine, soapmaking, and adulterating almond and olive oils.
Sunflower oil	Seeds of *Helianthas annuus* and *perennis*	.924 to .926	5°	Wool dressing, soapmaking, burning, adulterating olive oil.
Hazelnut oil	*Caryllus avellana*	.920 to .926	14° to 3°	Perfumery, in pharmacy as a substitute for almond oil.
Camelina oil	Seeds of *Myagrum sativum*	.925 to .926	0°	Burning, painting.
Beechnut oil	*Fagus sylvatica*	.920 to .922	27°	In France for cooking, burning, soapmaking.

III.—LINSEED OIL GROUP. VEGETABLE DRYING OILS.

Kind of Oil.	Source.	Specific Gravity.	Solidifying Point.	Uses.
Linseed oil	*Linum usitatissimum*	.930 to .937	−4° to −16°	Painting, varnishes, &c., soft soap, oil-cloth making
Hempseed oil	*Cannabis sativa*	.925 to .931	−5° to −18°	Do. do. do.
Poppyseed oil	*Papaver somniferum*	.924 to .927	0°	Culinary purposes, burning, painting, adulteration of olive oil.
Tobacco-seed oil	*Nicotiana tobacum*	.923	−13°	
Weldseed oil	*Reseda luteola*	.936	−4°	
Nigerseed oil	*Guizotia oleifera*	.924 to .928	14°	Adulteration of rape oil, and as a substitute for linseed oil.
Walnut oil	*Juglans regia*	.925 to .927	−5° to −18°	Paints and varnishes.
Scotch firseed oil	*Pinus sylvestris*	.931	−22°	

IV.—CASTOR OIL GROUP.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Solidifying Point ° F.	Uses.
Castor oil - -	Seeds of *Ricinus communis* -	.950 to .970	0°	Medicine, for making transparent soaps, lubricating heavy machinery.
Croton oil - -	Seeds of *Croton tiglium* - -	.942 to .955	...	Medicine.
Japanese wood oil -	Seeds of *Aleurites cordata* -	.937 to .940	below −8°	As a drying oil.
Manufactured—				
Boiled linseed oil -	Made by heating linseed oil .	.939 to .950	...	Paints, varnishes, and oil-cloth making.
Blown oils - -	Made by oxidising rape, cotton-seed, linseed, lard, and other oils	.942 to .971	...	Substitutes of castor oil for lubricating.

V.—PALM OIL GROUP.

Kind of Fat.	Source.	Specific Gravity.		Melting Point ° F.	Solidifying Point ° F.	Uses.
		At 60° F.	At 212° F.			
Palm oil - -	Fruit of *Avoira elais* or *Elais guineensis*	.920 to .927	.857 to .859	77° to 97°	68° to 97°	Railway grease, soapmaking, candlemaking, &c.
Cacao butter -	Nuts of *Theobroma cacao*	.995	.857 to .858	86° to 93°	69°	Pharmacy, chocolate creams, high class toilet soaps.
Nutmeg butter - (Mace butter)	Nuts of *Myristica fragrans*	...	.898	113°	106° to 108°	Pharmacy, high class soaps.
Shea or Galam butter	Seeds of *Bassia Parkii*-	...	.859	82°	73° to 95°	Soapmaking.
Bassia or Illile oil -	Seeds of *Bassia latifolia*	.947	...	91.5°	88°	Soapmaking when tallow and palm oil are scarce.
Chinese tallow -	Berries of *Stillingia sebifera*	...	...	...	86° to 90°	
Manufactured—						
Cottonseed stearin -	From cottonseed oil -	...	.866	90°	...	Adulteration of lard and butter, butterine.

VI.—COCOANUT OIL GROUP.

Kind of Fat.	Source.	Specific Gravity at 212° F.	Melting Point ° F.	Solidifying Point ° F.	Uses.
Cocoanut oil	Nuts of *Cocos nucifera*	.868 to .874	68° to 82°	61° to 65°	Marine soap, night lights.
Palmnut or palm-kernel oil	Kernel of nut of *Avoira elais* or *Elais guineensis*	.866 to .837	86°	75° to 79°	Substitute for cocoanut oil.
Laurel oil	Fruit of *Laurus nobilis*	.878	...	...	Veterinary and quack medicines.
Manufactured—					
Cocoanut stearin	Obtained by the compression of cocoanut oil	.869 to .870	82° to 84°	79°	Soapmaking, night lights, &c.
Cocoanut olein	Do.	.871	54° to 65°	39° to 50°	Soapmaking.
Japan wax	Berries of *Rhus succedanea*, &c.	.874 to .877	122° to 127°	108° to 126°	Candlemaking.
Myrtle wax	Berries of *Myrica cerifera*	.875	104° to 111°	102° to 109°	Candlemaking.

VII.—LARD OIL GROUP.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Solidifying Point ° F.	Uses.
Neatsfoot oil	Feet of various animals	.914 to .916	below 32°	Lubricating clocks and leather dressing.
Bone oil	Extracted from bones by boiling or solvents	.914 to .916	variable	Soapmaking.
Manufactured—				
Lard oil	Obtained by compressing lard	.915	25° to 50°	Greasing wool, lubricating machinery, soapmaking.
Tallow oil	Obtained by compressing tallow	.916	32° to 46°	

VIII.—TALLOW GROUP. SOLID ANIMAL FATS.

Kind of Fat.	Source.	Specific Gr. at 212° F.	Melting Point ° F.	Solidifying Point ° F.	Uses.
Tallow, suet	From the ox and sheep	.860 to .863	97° to 120°	91° to 118°	Candles, soapmaking, lubricating
Lard	From abdomen and other parts of the hog	.860 to .861	81° to 113°	81° to 111°	Cooking, soapmaking, manufacture of factitious butter.
Horse fat	From the horse, &c.	.861	...	...	Soapmaking.
Bone fat	Bones of various animals	...	...	...	Cheap 'Brown Windsor' soaps.
Wool fat	Wool of sheep	.888	...	...	Preparation for the hair, &c.
Butter fat	Cows' milk	.867 to .870	84° to 95°	68° to 86°	Food, cooking.
Manufactured—					
Butterine, oleomargarine	From various animal and vegetable fats	.858.5 to .863	93° to 104°	64° to 100°	Substitute for butter.
Stearin	Obtained by pressing lard and tallow	...	129° to 136°	...	Candles, night lights, soapmaking.
Recovered fat ('Yorkshiregreese')	Treatment of soap suds, &c., with acids	...	...	...	Cheap candles, soap, &c.

IX.—WHALE OIL GROUP. MARINE ANIMAL OILS.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Uses.
Whale oil	Blubber of *Balæna misticetus* and various allied species	.920 to .931	Illumination, saw hardening, soapmaking.
Porpoise oil	Blubber of *Delphinus phocæna* and allied species	.920 to .930	Illumination, soapmaking, leather dressing, lubrication.
Seal oil	Blubber of *Phoca* of various species	.924 to .929	Burning in safety lamps, lubrication, adulteration of cod liver oil. Produces a very offensive smelling soap.
Menhaden oil	*Alosa menhaden*	.927 to .933	Adulteration of linseed oil
Cod oil	Fat of cod and other fish	.923 to .932	Leather dressing.
Cod liver oil	Liver of the various species of *Gadus*	.925 to .931	Medicine, leather dressing.
Shark liver oil	*Squalus maximus* (basking shark or sunfish) and allied species	.911 to .929	Leather dressing, and adulteration of cod liver oil.

X.—SPERM OIL GROUP. LIQUID WAXES.

Kind of Oil.	Source.	Specific Gravity at 60° F.	Uses.
Sperm oil -	Blubber and cranial cavities of *Physeter macrocephalus*	.875 to .884	Lubrication of light machinery, hardening of steel weapons
Dœling oil or bottlenose oil	Blubber.&c., *Hyperoodon rostratus* and *H. bidens*	.876 to .881	Substitute for and adulteration of sperm oil.
Dolphin oil -	Blubber,&c., of *Delphinus globiceps*	.922	Do.

XI.—SPERMACETI GROUP. WAXES PROPER.

The bodies which come under this group are spermaceti, beeswax, Chinese wax, opium wax, palm wax, Carnaüba or Brazil wax. They have specific gravities ranging from .808 to .842, and have melting points ranging from 110° F. to 185° F. These substances are difficultly inflammable, but burn rapidly when kindled.

FLASH POINTS OF THE FIXED OILS.

Kind of Oil.	Flash Point ° F.
Fish Oils—	
Sperm - - - - - - - -	520° to 530°
Whale - - - - - - - -	590° to 595°
Vegetable Oils—	
Olive - - - - - - - -	550° to 570°
Castor - - - - - - - -	540° to 545°
English cottonseed - - - - - -	575° to 585°
American cottonseed - - - - -	over 600°
Stettin rape - - - - - - -	575°
English rape - - - - - - -	560° to 580°
Lisbonseed - - - - - - -	515° to 520°
Groundnut - - - - - - -	560° to 570°
Animal Oils—	
Lard - - - - - - - -	575° to 590°
Tallow, Neatsfoot (American) - - - -	525° to 535°

(D.) ESSENTIAL OR VOLATILE OILS.

Source.—These substances are present in more or less quantity in all odoriferous plants, from which they are extracted by the following processes :—

(1.) By subjecting the plant or seeds, &c., to pressure.

(2.) By distillation with water, or passing steam over the crushed material and condensing.

(3.) Some oils, such as the essential oils of mustard and bitter almonds, do not pre-exist in the seeds of the plants, but are produced by fermentation, and afterwards separated by process (2).

(4.) By dissolving out the oil of the substance by an inodorous *fixed oil*, such as oil of ben or poppy oil.

Characters.—Essential oils are generally of a yellowish colour, but darken considerably on exposure to light or air. The chemical constitution of them varies considerably. Some consist principally of the hydrocarbons terpenes ($C_{10}H_{16}$), cedrenes ($C_{15}H_{24}$), and their allied oxidised products, while others consist chiefly of aromatic aldehydes and allied bodies, ethereal salts, &c. They are somewhat volatile at the ordinary temperature, giving marked odours characteristic of their source. They are very inflammable, and rapidly absorb oxygen from the air. They vary in specific gravities from 0.850 to 1.16. Water dissolves traces of essential oils retaining their odours. They are readily soluble in alcohol, ether, petroleum spirit, and carbon bisulphide. Unlike the fixed oils and fats, they are not generally converted into soaps or *saponified* by alkalies. They are, however, decomposed by sulphuric and nitric acids.

Uses.—Perfumes, scented toilet soaps, medicine.

The following is a list of the more important essential oils, with their specific gravities :—

Name of Oils.	Specific Gravity.
Oil of bitter almonds	.960
,, amber rect.	.858
,, angelica root	.898
,, anise, Russian	.981
,, ,, very old	.890
,, ,, star, fresh	.976
,, bergamot	.875
,, cajeput	.920
,, calamus	.920 to .940
,, cardamom	.980
,, caraway	.945
,, ,, old	.955
,, cloves	1.060
,, copaiba	.920
,, coriander	.880
,, cubebs	.945
,, ,,	.920
,, dill	.880
,, eucalyptus	.900
,, fennel	.990
,, Juniper berries	.850
,, lavender	.890
,, ,, old	.888
,, lemon	.870
,, mace	.895
,, marjoram	.901
,, neroli	.870
,, orange, sweet	.850
,, ,, bitter	.876
,, parsley	.950
,, peppermint	.915
,, ,, very old	.925
,, rose	.860
,, rosemary, French	.894
,, ,, Italian	.904
,, rue	.890

Name of Oils.	Specific Gravity.
Oil of savin	.898
,, sage	.920
,, santal	.980
,, thyme	.895
,, turpentine	.890
,, verbena	.895
,, winter-green	1.158
,, wormseed, Levant	.920
,, wormwood (absinthe)	.965
,, ,, (chenopod)	.960

OIL OF TURPENTINE.

Synonyms.—*Turps, Spirit of Turpentine, Turpentine, Oleum Terebinthinæ,* $C_{10}H_{16}$.

Source.—Oil of turpentine is obtained from the oleoresinous exudations from the wood, bark, and leaves of pine and fir trees. By distillation, the substance yields from 10 to 25 per cent. of turpentine, which is further purified, and the residuum being common rosin or colophony. The countries supplying the principal part of the oil are France, America, and Russia.

Characters.—Pure turpentine is a volatile, colourless, pleasant smelling liquid hydrocarbon, of a pungent bitter taste. It has a specific gravity of .864 to .870, and gives off inflammable vapour at about 93° F. It begins to boil at between 313° F. and 320° F., and is completely distilled at about 338° F. Oil of turpentine is very inflammable, and burns with a very smoky flame. It is insoluble in water, but readily soluble in alcohol, ether, benzol, naphtha, fixed and essential oils. It is a solvent for sulphur, phosphorus, resins, and fats. It is antiseptic and disinfectant, and on exposure to the air it oxidises, forming camphoric peroxide. "*Sanitas*," the well-known disinfectant, is produced by passing air through warm turpentine and water, hydrogen peroxide and camphoric acid being formed, which are dissolved by the water.

Venice turpentine is a mixture of 8 parts of common yellow or black rosin with 5 parts of oil of turpentine.

Strasburg turpentine is obtained from the silver fir, and is usually of a yellowish-brown colour.

Uses.—Turpentine is extensively used as a solvent and diluent for varnishes, paints, &c., for the production of "*Sanitas*," and in medicine it is much in demand as a liniment for inflammatory diseases such as bronchitis.

(E.) VARIOUS HIGHLY INFLAMMABLE LIQUIDS.

ACETONE.

Synonyms.—*Dimethyl Ketone*, *Pyroacetic Spirit*, C_3H_6O.

Source.—This substance is produced when the vapour of acetic acid is passed through a red-hot tube, or by subjecting metallic acetates to destructive distillation.

Characters.—Acetone is a colourless limpid liquid of characteristic odour. It has a specific gravity of 0.792, and boils at 132° F. It is highly inflammable, its vapour igniting at the ordinary temperature, burning with a bright flame. It is readily soluble in water, alcohol, and ether.

Uses.—As a solvent for resins, gums, and camphors.

BISULPHIDE OF CARBON.

Synonyms.—*Disulphide of Carbon*, *Carbonic Disulphide*, *Sulpho-Carbonic Acid*, CS_2.

Source.—Bisulphide of carbon of commerce is prepared by passing the vapour of sulphur through red-hot charcoal contained in a metallic cylinder. The sulphur vapour combines with the charcoal, forming gaseous bisulphide of carbon, which is drawn off into cylindrical drums, kept cool with water, and then condensed and drawn off into receptacles from time to time, and afterwards redistilled.

Characters.—Bisulphide of carbon, when pure, is a very refractive, colourless, and volatile, mobile liquid, with a specific gravity of 1.272 at 600° F., and a molecular weight of 76, and vapour density of 2.626. It boils at 118° F. Its percentage composition is carbon, 15.79; sulphur, 84.21. It is a very inflammable liquid, and burns with a blue flame, with the production of carbon dioxide and sulphur dioxide. When its vapour is mixed with air, hydrogen, or carbonic acid, a highly explosive gas is produced. A mixture of air and the bisulphide vapour explodes at so low a temperature as 300° F. Great care is therefore necessary in dealing with this substance, especially in the prevention of leaks in the vessels containing it. For special conditions for its conveyance, see page 325.

Although carbon bisulphide, when absolutely pure, is practically odourless, the commercial variety has a most repulsive odour, due to the presence of small quantities of sulphuretted impurities. Its vapour is very poisonous. When breathed, it produces great depression and nausea, and eventually coma. It is practically insoluble in water, in which it sinks, being about 1¼ times as heavy. It is freely soluble in alcohol and ether, and is a solvent for essential oils, sulphur, phosphorus, iodine, and various gums and resins. On exposure to sunlight, the bisulphide deposits a reddish powder, which appears to be a monosulphide of carbon (CS).

Uses.—The applications of carbon bisulphide in the arts are important and extensive. It is largely used for the solution and vulcanisation of caoutchouc and guttapercha, for the extraction of alkaloids such as quinine, the oleaginous and aromatic constituents of flowers, spices, seeds, roots, &c. It is an excellent germicide and insecticide, and advantage is taken of this property to destroy germs and insects that sometimes infect grain, seeds, &c. A small quantity of the liquid is sprinkled over the grain contained in an air-tight room. After exposure for a few hours, all organisms are destroyed, after which the bisulphide is readily evaporated on exposure to the air, the grain suffering no damage from the treatment.

CHLOROFORM.

Synonyms.—*Trichlormethane*, *Chloroformum*, $CHCl_3$.

Source.—Chloroform may be obtained by heating chloral with an aqueous solution of potassium hydrate (*caustic potash*). It is, however, generally prepared for commerce by distillating a mixture of alcohol, water, and chloride of lime (*bleaching powder*), and the resulting distillate of chloroform rectified.

Characters.—This important anæsthetic is a thin, colourless, ethereal smelling liquid, with a molecular weight of 119.5. It is 1.48 times as heavy as water, and boils at 142° F. It has a sweet taste, and inflames when mixed with alcohol, and burns with a greenish flame. It is slightly soluble in water, but is readily soluble in alcohol and ether. A little alcohol is generally added to chloroform to preserve it from decomposition, because in the pure state it soon becomes acid and gives off irritating vapours.

Uses.—As a solvent for oils and fats. In medicine, an aqueous solution containing 1 of chloroform to 200 of water, and known as *aqua chloroformi*, is given internally in doses from $\frac{1}{2}$ to 2 fluid ounces, as a stimulant and for mixing with nauseous drugs. The principal use of chloroform is as an anæsthetic, the inhalation of its vapour having the remarkable effect upon the animal system of making it insensible to pain, so that surgical operations, amputations, &c., can be performed without pain when the patient is under its influence.

ETHER.

Synonyms.—*Ethylic Ether*, *Sulphuric Ether*, *Æther*, *Methylated Ether*, $(C_2H_5)_2O$.

Source.—This compound is prepared by distilling equal parts of alcohol and sulphuric acid in a retort, and collecting the distillate of ether in a cool receiver. The distillation is stopped as soon as the contents of the retort begin to blacken and froth. The ether is purified by redistilling with caustic soda at a gentle heat.

Characters.—Pure ether is a very thin, colourless, volatile, transparent, fragrant, and mobile liquid. It has a molecular weight of 74, and is much lighter than water, its specific gravity being 0.720. It has a burning taste, and is highly inflammable, its flame being white. It gives off inflammable vapour at the ordinary temperature, and boils at 96° F. Although ether is such a light liquid, its vapour is 2.586 times as heavy as the atmosphere. When mixed with oxygen gas it explodes with great violence on the application of flame. Ether is soluble in water to the extent of about 10 per cent., and is miscible with alcohol in all proportions. It is a solvent for oils and fats. When ether is placed upon the hand or other parts of the body, it evaporates so quickly that it produces great cold and numbness. When breathed with air, it acts as an anæsthetic, but is not nearly so powerful in this respect as chloroform.

Uses.—As a solvent for oils, fats, odoriferous principles, &c. As a general anæsthetic, associated with other drugs, it is an excellent cardiac (heart) stimulant. Much used in photography.

ETHYLIC ALCOHOL.

Synonyms.—*Alcohol, Absolute Alcohol, Alcohol Ethylicum, Spirits of Wine,* C_2H_6O.

Source.—This important liquid is produced from solutions containing sugars by a process of fermentation and distillation. If a saccharine liquid is mixed with a small quantity of *yeast*—the product deposited from beer during its fermentation—and maintained at a temperature of 70° F., effervescence soon takes place, carbonic acid gas being given off, and alcohol produced in solution, from which it can be obtained by distillation, redistillation, and rectification. Absolute alcohol is obtained from the strongest spirit of wine of commerce, which contains about 16 per cent. of water, by redistilling it with half its weight of caustic lime. Spirits, such as brandy, whisky, gin, and rum, are all alcohol distillates obtained from fermented liquids, such as those produced from such grains as wheat, barley, rye, Indian corn, rice, &c. French brandy or "cognac" is distilled from wine, and Jamaica rum from the fermented solution of sugar or molasses. Malt liquors, such as beer, stout, &c., wines, such as port, sherry, &c., are alcoholic liquids, produced by the fermentation of grain, juices of fruit, &c., and are not distilled products, and contain, besides alcohol, various other principles characteristic of their sources.

Characters.—Pure absolute alcohol is a colourless, limpid liquid, with an agreeable pungent odour and taste. It has a molecular weight of 46, and specific gravity of 0.7938. It boils at 173° F., and freezes at –203° F. It is highly inflammable, and burns with a pale bluish flame, and flashes at the ordinary temperature. It is hygroscopic, and absorbs water from the air. It is soluble in water in all proportions, and in the act of dilution a contraction in volume takes place with a rise in temperature of the liquid. It is a solvent for a great number of organic and inorganic substances.

Rectified spirit of wine is the name given to the most concentrated alcohol that can be obtained by distillation without the addition of dehydrants such as lime. The *spiritus rectificatus* of the British Pharmacopœia contains 84 per cent. by weight of alcohol, and has a specific gravity of 0.838.

Proof spirit of the British Pharmacopœia contains 49 per cent. of alcohol, the specific gravity being 0.920. By Act of Parliament, *proof spirit* is now defined to be a liquid of such density that at 51° F. 13 volumes shall weigh the same as 12 volumes of water at the same temperature, and has a specific gravity of 0.91894 at 60° F., and contains 49.24 per cent. of alcohol by weight. Spirits containing less alcohol than the above are described by the Excise authorities as being so many degrees or so much per cent. *under proof* (U.P.). Thus by the term spirit of 20 per cent. or 20° U.P. is meant a liquid containing at 60° F. 80 measures of proof spirit and 20 of water.

Spirit of 50° U.P. is a liquid containing equal volumes of proof spirit and water, while pure water is 100° U.P. Spirits stronger than proof are described according to the number of measures of proof spirit 100 volumes would yield when suitably diluted. Thus spirits of 50° over proof (O.P.) is alcohol of such strength that 100 measures at 60° F., when diluted with water to 150 measures, would be proof spirit. Absolute alcohol is consequently 75¼° O.P., and contains 175¼ per cent. of proof spirit, since 100 measures when diluted with water would produce 175¼ measures of proof strength.

The following table shows the percentages of ethylic alcohol in various spirituous liquids:—

	Per cent. of Alcohol.
Absolute alcohol	98 to 100
Rectified spirit = (B.P.)	84
Spiritus vini Gallici	48 " 56
Alcohol dilutum (U.S.P.)	54.5
Whisky and brandy	44 " 50
Rum, gin, and liqueurs	40 " 50
Spiritus tenuior	49
Vinum album fortius (U.S.P.) ...	20 " 25
Port	15 " 25
Sherry and Madeira	15 " 20
Champagne	10 " 13
Burgundy	10 " 13
Hock	10 " 12
Claret	8 " 12
Vinum album (U.S.P.)	10 " 12
Vinum aurantii	10 " 12
Cider	5 " 9
Strong ale or stout	5 " 9
Beer and porter	2 " 5
Koumiss	1 " 3

The stronger alcoholic liquids are highly inflammable.

Methylated Alcohol or Methylated Spirits.—This is a liquid containing 90 per cent. of ethylic alcohol and 10 per cent. of methyl alcohol, and till recently was an unexcisable spirit; but owing to large quantities having been used for dietetic purposes, its manufacture and sale is now restricted, and to take its place the ethylic alcohol is mixed with mineral naphtha, which renders it unfit for drinking.

Uses.—The applications of alcohol are very important and extensive. It is used as a solvent in the arts and manufactures. In medicine its uses are numerous, for tinctures, liniments; as an antiseptic, stimulant, disinfectant, and refrigerant. It is a constituent of all fermented liquids and spirits. It is in constant use by the analyst, druggist, and photographer. The naphtha spirit is used in the manufacture of spirit varnishes, French polish, for burning in spirit lamps, &c. &c.

METHYL ALCOHOL.

Synonyms. — *Wood Spirit*, *Wood Naphtha*, *Pyroxylic Spirit*, CH_3HO.

Source.—This substance is found in the liquid resulting from the dry distillation of wood and other organic substances to the extent of about 1 per cent., and is separated from the accompanying acetic acid, tarry matters, &c., by fractional distillation, and the weak spirit thus produced dehydrated with lime and redistilled.

Characters.—Pure methyl alcohol is a thin, colourless, mobile liquid, having a spirituous odour and a disagreeable burning taste. It has a specific gravity of 0.800, and boils at 152° F. It is highly inflammable, and burns with a non-luminous flame. It is soluble in water, alcohol, and ether, in all proportions, and it is a solvent for resins, essential oils, &c. It dissolves caustic soda and potash, producing a brown solution.

Uses.—Used for mixing with ethylic alcohol to the extent of 10 per cent., and then constitutes "methylated spirits." For burning in spirit lamps, for mixing with paints and varnishes, and many other purposes for which ordinary alcohol is used.

AMYLIC ALCOHOL.

Synonyms.—*Isobutyl Carbinol, Fusel Oil, Potato Spirit,* $C_5H_{12}O$.

Source.—This substance is obtained from the spirit produced from the fermentation and distillation of potato and grain mash. The liquid produced by the distillation of fermented potato is washed with water, and the insoluble portion subjected to distillation, and the portion of liquid distilled between 260° and 280° F. is redistilled until it has a fixed boiling point of 268° to 270° F.

Characters.—Pure amylic alcohol is a thin, colourless liquid, having a characteristic pungent odour, and a sharp burning taste. It has a specific gravity of .816, and boils at 270° F., giving off highly inflammable vapour. It is sparingly soluble in water, but freely soluble in alcohol, ether, chloroform, benzol, and oils. The vapour of the alcohol, when breathed, irritates the air passages and causes coughing. It readily burns with a smoky flame. It makes a gradual evanescent oil spot upon paper.

Crude *fusel oil* or *potato spirit* contains a number of compounds other than amylic alcohol.

Uses. — For the manufacture of nitrite of amyl and valerianate of sodium. Is a constituent of certain anti-fouling compositions and varnishes, and is often used in lecture demonstrations.

Relative Degree of Danger of certain Inflammable Liquids. (Dr Gantter Heilbronn.)

Liquid.	Flash Point ° F.	Permanent Ignition Point ° F.	Relative Degree of Danger.
Ethyl ether	-4.0	-4.0	100.0
Carbon disulphide	-4.0	-4.0	100.0
Petroleum ether (sp. gr. 0.70)	-4.0	-4.0	100.0
Benzol (90 per cent. strength)	5.0	5.0	99.0
Benzol (50 per cent. strength)	23.0	23.0	97.0
Methyl alcohol	32.0	32.0	96.0
Toluol	44.6	70.0	94.5
Ethyl alcohol (95 per cent.)	57.2	59.0	93.4
Ethyl alcohol (60 per cent.)	60.8	80.6	92.8
Ethyl alcohol (45 per cent.)	68.0	87.8	92.0
Petroleum (burning)	77.0	109.4	91.0
Xylol from coal tar	86.0	116.6	90.0
Oil of turpentine	95.0	112.2	89.0
Cumol from coal tar	102.1	132.8	88.2
Anhydrous vinegar	111.2	167.0	87.2
Amyl alcohol (fusel oil)	114.8	116.6	86.8
Solar oil	140.0	176.0	84.0
Tar oil (dead oil)	145.4	181.4	83.4
Aniline	168.8	217.4	80.8
Dimethyl aniline	168.8	194.0	80.8
Aniline for red	185.0	221.0	79.0
Toluidin	185.0	224.6	79.0
Nitrobenzole	194.0	217.4	78.0
Xylidin	206.6	249.8	76.6
Paraffin oil	224.6	302.0	74.6
Naphthaline	392.0	440.6	56.6

INDIARUBBER SOLUTION.

Early in 1894, Mr Boverton Redwood, F.R.S.E., had occasion to examine a consignment of this solution, stored at Galleons Basin. The stuff was packed in tin boxes 7 inches in diameter and 3 inches in depth, with slip covers, and contained in a case. The tins were wrapped in rolls of rug material, and the whole enclosed in waterproof cloth. Some of the tins were considerably damaged, and in a leaking condition. The danger attending the transport of highly inflammable goods packed in this careless fashion can be imagined when the flash point of the rubber solution in question was found to be as low as 31° F. In concluding his report upon the subject, Mr Redwood said that "had the case been stowed in a confined and unventilated part of a ship, the surrounding atmosphere would soon have been brought into a condition in which the introduction of a light could not have failed to have caused a disastrous explosion, and probably set up a conflagration."

The outcome of this inquiry led the Marine Department of the Board of Trade to issue, in May 1894, a memorandum addressed to the Detaining and Emigration Officers, the substance of which here follows:—

"The Board of Trade are advised that this material comes under the heading of Dangerous Goods; and that if stowed under deck it should be placed where it is easily accessible, and that it should on no account be treated as general cargo and covered with other goods.

"Emigration Officers should not allow rubber solution to be loaded on board passenger ships (*see* Section 29 of the 'Passengers Act, 1855'), and in the event of the material being in any case shipped in such a manner as, in the opinion of a Detaining Officer, to render a ship unfit to proceed to sea without serious danger to human life, he should not hesitate to order provisional detention, if necessary, under Section 6 of the Merchant Shipping Act, 1876,* referring to the Board of Trade if he is in doubt or difficulty."

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* *See* now Merchant Shipping Act 1894.

SECTION VI.

INFLAMMABLE SOLIDS.

EXPLOSIVE DUSTS.

COMBUSTIBLE substances, when in a very finely divided condition, expose a larger surface to the action of the oxygen in the atmosphere than when in a compact state, and consequently burn with greater rapidity. For instance, the highest temperature of the blacksmith's forge is required to burn a piece of solid iron ; but if the metal be in a very finely divided condition, such as is produced by the reduction of its oxide by hydrogen gas, mere falling through the atmosphere inflames it. A similar principle can be applied to cases of so-called "*spontaneous combustion.*" A heap of cotton waste is saturated with an oil—such as linseed—that has the property of absorbing or combining with oxygen ; it is exposed to the atmosphere for some time ; here the heat generated by the rapid absorption of the oil, consequent upon the large area exposed in the interior of the waste, is often so great as to cause the inflammation of the heap. Serious conflagrations are frequently traced to this cause. Light organic dry dusts, such as those of coal, fluor, wood, &c., when present in the atmosphere in certain proportions, form an inflammable mixture which is liable to explode with extreme violence from a spark or flame. In a lecture delivered by Sir F. Abel, C.B., F.R.S., in 1882, before the Royal Society, upon the subject, he said :—

"The combustion of the finely divided particles which under such conditions are first inflamed, at once communicates flames to those in their immediate vicinity, and combustion is thus transmitted, by and through the surrounding mixture of dust and air, with a rapidity regulated by the inflammability of the dust and by the proportion and state of division in which it is distributed through the air. If a rapidly burning mixture of the kind is confined, its combustion is attended by explosive effects, the degree of violence of which is determined by the combustibility of the dust, by the quantity of mixture ignited, and the nature of confinement. Its behaviour, indeed, is quite similar to that of a mixture of inflammable gas or vapour, and of air. At the instant of its ignition each dust particle is, to a more or less considerable extent, converted into inflammable vapour, or is at any rate surrounded by an envelope of burning vapour, so that if the particles are in sufficiently close proximity to each other, the rapidly successive development of vapour from them as the flame spreads gives rise to a condition of things very like that which is obtained when an inflammable gas or vapour, originally existing as such, is mixed with air."

No doubt the intensity of combustion or explosion depends upon the temperature of the air, humidity of air and dust, together with the degree of fineness and composition of the dust, also the nature of the products of combustion (*see* p. 231).

CAMPHOR.

Synonyms.—*Laurel Camphor*, *Camphora*, $C_{10}H_{16}O$.

Source.—This substance is produced from the wood of the *Cinnamomum camphora*, occurring in the East Indies, China, and Japan. The wood is distilled with water, when a rough camphor is condensed, which is afterwards purified by resublimation.

Characters.—Common camphor is a solid, colourless, translucent, crystalline, and inflammable body. It is somewhat volatile, and gives off a characteristic flagrant odour. Its taste is pungent and bitter, and produces a sensation of cold. Camphor floats on water, its specific gravity varying from .986 to .996. It melts at 347° F., and boils at 400° F., giving off very inflammable vapour. Camphor is but slightly soluble in water (1 in 1000), but is readily dissolved by alcohol, ether, chloroform, acetic acid, bisulphide of carbon, and oils.

Menthol is another form of camphor, obtained from oil of peppermint by cooling, from which it is deposited in snow-white acicular crystals. Volatile, giving off a most ethereal odour. It is much used as a relief for headache and neuralgia.

Thymol is a camphor obtained from thyme oil, and consists of large, oblique, prismatic crystals. Oil of thyme has a pungent aromatic taste, and is used in medicine as an antiseptic and antiparasitic.

Uses.—Camphor is a constituent of a great number of pharmaceutical preparations. It is used to keep away insects, such as moths, &c., from clothes. In combination with naphthalene and other slightly volatile bodies, it is applied, as tablets, as a disinfectant for urinal pans, &c. It is a constituent of *celluloid*, *xylonite*, *coralline*, *artificial ivory*. These substances are mixtures of nitro-compounds, such as gun-cotton, nitrated wood and paper, &c., and camphor, and are manufactured into combs, pipe stems, brush backs, mirror frames, and numerous nicknacks, as a substitute for ivory, amber, and vulcanite. These bodies are highly inflammable, and dangerous to manufacture. The soot from burning camphor is used by riflemen to darken the "sights" of their weapons, and in the manufacture of Indian inks.

MAGNESIUM.

Synonym.—*Mg.*

Source.—Magnesium in combination is found in abundance in nature. *Dolomite* is a double carbonate of magnesium and lime, also known as magnesian limestone. In combination with silica it constitutes the minerals hornblende, talc, steatite, asbestos, soapstone, &c. The metal is prepared by heating magnesium chloride and potassic (or sodic) chloride with metallic sodium.

Characters.—Magnesium is a silvery white metal, ductile, and capable of taking a high polish, and is not acted upon to any great extent in the atmosphere. It has an atomic weight of 24, and is 1.743 times as heavy as water. Magnesium is acted upon but slightly by water, but is readily soluble in dilute acids. When thrown into strong hydrochloric acid, it bursts into flame. Magnesium is readily kindled by a flame, and burns with a brilliant dazzling white light, forming the white compound magnesia.

Uses.—As an artificial light in photography, lecture demonstrations, &c.

PHOSPHORUS (P).

Source. — Phosphorus is obtained from the bones of animals, in which it exists as calcic phosphate (bone phosphate), or from the native phosphate of lime, as follows :—The bones having been treated for the extraction of the albumens—*gelatine*, &c.—by heating them under pressure with water, are then calcined in a furnace. The bone ash thus produced is finely powdered, and mixed with sufficient dilute sulphuric acid to extract about two-thirds of the lime associated with the phosphorus. The mixture is allowed to stand for some time, after which it is separated from the sulphate of lime formed, by filtration. The filtrate is now evaporated to a syrup, and mixed with from one-fourth to one-half its weight of charcoal, and then heated to expel the water. The porous mixture is now transferred to a retort fitted with an "adapter," connected with a receiver containing water, and gradually heated to redness. Phosphorus is distilled over, and sinks in globules in the water, after which it is purified and cast into sticks under water. A further quantity of phosphorus is obtained by mixing the residue in the retort with sand and again heating.

Characters. — Pure phosphorus is a nearly colourless, semi-transparent, and waxlike solid. At the ordinary temperature it is about as soft as bees'-wax, although at lower temperatures it is hard and brittle. The element has an atomic weight of 31, and the specific gravity is 1.8. It melts at 112° F., and boils at about 550° F. It oxidises in the air at ordinary temperatures, giving off white vapours of a garlic-like odour, which consist of peroxide of phosphorus, &c. In the dark, this slow combustion gives out a greenish white light.

Phosphorus is extremely inflammable, and ignites in the atmosphere at a temperature very little above its melting-point, a trifling friction also effects its ignition. It is therefore necessary to keep it in water, and also to cut it under water when small quantities are required. Great care is always necessary in handling this substance; very severe burns and fatal accidents have resulted from its careless manipulation. Phosphorus is insoluble in water, but soluble to some extent in ether, benzol, turpentine, and oils. It is freely soluble in bisulphide of carbon and chloride of sulphur. The fumes from phosphorus are poisonous, and frequent inhalation of them produces gastro-intestinal irritation and necrosis of the bone, and the solid taken internally acts as a very powerful irritant poison. It detonates when rubbed with chlorate of potash and nitre.

Red or Amorphous Phosphorus.—The wax-like phosphorus is capable under certain conditions of being converted into an allotropic form, and its physical characteristics radically changed. This variety is prepared by heating ordinary phosphorus to about 445° F. in a current of carbonic acid gas, and maintained at this temperature for some hours. Its specific gravity is increased to 2.2, it undergoes no change when exposed to air or light, and does not take fire until a temperature of 480° F. is reached. It is unnecessary to preserve this variety under water, and it is non-poisonous. If heated in air to about 490° F., it is converted into the yellow variety, and bursts into flame, giving off white vapours of phosphorus pentoxide.

Uses.—The principal applications of phosphorus are in the manufacture of lucifer matches, and in the preparation of the igniting surface on safety match boxes, and is an ingredient of certain vermin pastes. It is not greatly used in the laboratory. It is used in lecture demonstrations for the preparation of phosphuretted hydrogen gas, &c. Phosphorus is sometimes used, in medicine always, in conjunction with other ingredients, and containing $\frac{1}{50}$th to $\frac{1}{20}$th of a grain per dose. It is of questionable value in diseases, very little being known of its therapeutic action.

POTASSIUM.

Synonyms.—*Kalium*, *K*.

Source.—This metallic element is obtained by distilling carbonate of potash and charcoal in an iron retort. Carbonic oxide gas is evolved, and metallic potassium is condensed in special receivers, after which it is redistilled to separate impurities.

Characters.—Potassium is a remarkable bluish-white metal. At the ordinary temperature it is soft, and may be cut with a knife, the fresh surfaces exhibiting a brilliant metallic lustre. At low temperatures it is brittle. It has a specific gravity of 0.865, and an atomic weight of 39.1, and melts at 144° F., and when strongly heated, volatilises and burns with a violet flame. It rapidly oxidises on exposure to the atmosphere, and has consequently to be preserved in liquids that contain no oxygen, such as naphtha. Potassium has the remarkable property of decomposing water at the ordinary temperature. If a little of the metal is thrown on water, it floats and decomposes it so energetically, that the liberated hydrogen takes fire and burns with a violet flame upon the surface of the water, which becomes a solution of the hydrate of the metal (caustic potash), and which has a strong alkaline reaction.

Uses.—Limited applications. For lecture demonstrations and certain analytical operations.

ROSIN.

Synonyms.—*Colophony*, *Common Resin*, *Resina.*

Source.—Common resin or rosin is obtained as a residuum in the distillation of oil of turpentine from the crude oleo-resinous exudations from the various species of *Pinus.*

Characters.—Colophony consists of several resin acids and anhydrides, abietic anhydride predominating. It is a transparent amber or reddish coloured brittle solid, with a specific gravity of from 1.04 to 1.10. It has a slight odour of turpentine, and possesses a peculiar nauseous taste. It softens at the boiling point of water, and becomes fluid at about 275° F. It burns rapidly when kindled, with a dense yellow sooty flame, giving out a peculiar odour. It is insoluble in water, but is soluble in warm alcohol, acetic acid, and ether. Treatment with caustic alkalies converts it into a brown resin soap, soluble in water.

Common resin or colophony may be taken as a typical example, as far as danger from inflammability, transport, &c., is concerned, to a number of resinous substances possessing more or less similar chemical characteristics, although some have notable physical differences. Resins which contain mucilage or gum are called gum-resins, while those which are associated with essential or volatile oils are termed balsams, turpentines, or oleo-resins. The following are a list of the more important of these bodies:—*Common Resin or Colophony*, *Caoutchouc* (*Indiarubber*), *Shellac*, *Dammar*, *Copal*, *Gutta-percha*, *Benzoin*, *Guaiacum*, *Amber*, *Sandarac*, *Mastic*, *Tolu.*

These bodies, which are all more or less inflammable, have specific gravities ranging from .96 to 1.24.

Uses.—Resin is a constituent of a number of varnishes and soaps, French polishes, plasters, &c. Caoutchouc (or indiarubber) is manufactured into an endless variety of articles. Guttapercha is extensively used to insulate electrical wires. Guaiacum is used in medicine. Amber is a hard resin, and is capable of being highly polished, and manufactured into useful articles, notably tobacco pipe stems.

SODIUM.

Synonyms.—*Natrium*, *Na.*

Source.—This metallic element is obtained by distilling carbonate of sodium and charcoal in an iron retort. Carbonic oxide gas is evolved, and metallic sodium is condensed in special receivers, after which it is redistilled to separate impurities. It is a constituent of common salt (sodium chloride), in which it exists to the extent of 39.3 per cent.

Characters.—Sodium is a bluish-white metal. At the ordinary temperature it is soft, and may be cut with a knife, the fresh surfaces exhibiting a brilliant metallic lustre. At low temperatures it is brittle. It has an atomic weight of 23, and a specific gravity of 0.972. It melts at 207° F. On exposure to the air it rapidly oxidises, forming sodium oxide, and upon heating strongly it burns with a yellow flame. It decomposes water at the ordinary temperature with the liberation of hydrogen and formation of sodium hydrate (*caustic soda*). Sodium has not quite so energetic an action upon water as potassium. The hydrogen liberated does not inflame unless the water is previously heated, or a light applied to the issuing gas. It should be preserved in naphtha.

Uses.—For the production of aluminium and certain other elements difficult of reduction. Lecture demonstration and in analytical chemistry.

SULPHUR.

Synonyms.—*Brimstone*, *Flowers of Sulphur*, *Sulphur Sublimatum*, *Sulphur Precipitatum*, *S.*

Source.—Sulphur occurs in nature in a free state in abundance, and also in combination with many metals as sulphides. The principal source of the element is from Sicily, where it occurs in beds, running from the southern coast to Mount Etna. It also occurs in many other volcanic localities, such as South America, Mexico, and Italy.

Characters.—Sulphur is found in nature in transparent yellow crystals, or in yellow amorphous masses. Commercial sulphur is termed *flowers of sulphur* when in powder, and *brimstone* when in round sticks, this variety being very brittle. There are three allotropic modifications of sulphur known, which are distinguished by differences in crystalline form and solubility in bisulphide of carbon. It has an atomic weight of 32. Native sulphur has a specific gravity of 2.05, artificial crystalline needles of the element show a specific gravity of 1.98, and the plastic variety, which is insoluble in carbon bisulphide, 1.95. Sulphur melts at 239° F., and boils and distils at about 836° F., its vapour being of a deep yellow colour. It is very inflammable, and takes fire when heated in air between 455° and 500° F., burning with a blue flame and giving off suffocating fumes of sulphurous anhydride. When sulphur is heated to about 500° F., and the liquid poured in a stream into cold water, it assumes a plastic condition which may be drawn out into elastic threads. It is insoluble in water, and is a bad conductor of heat and electricity.

Uses.—Sulphur has important and extensive applications in the arts and manufactures. Large quantities are consumed in the manufacture of gunpowder, matches, fireworks, and sulphuric acid. It is now much applied in the form of candles for fumigating infected hospital wards, &c., and for the destruction of domestic vermin, the sulphurous vapour from burning sulphur being a powerful disinfectant and vermicide. It is also much used in medicine, in combination with sugar, gum, &c., in the form of lozenges or tablets for certain cutaneous complaints.

SECTION VII.

MISCELLANEOUS SUBSTANCES.

BROMINE.

Synonyms.—*Bromum*, *Br*.

Source.—This element exists in combination with magnesium in sea water to the extent of $\frac{1}{3}$ to 1 grain per gallon, and also in many brine springs. The following is the process adopted for its extraction from sea water:—The water, after being evaporated so as to remove the crystallisable salts, such as sodium chloride, &c., the mother liquor, which is called *bittern*, and contains all the bromine, is exposed to the action of chlorine gas. By this means the bromine is liberated from its combination with magnesium, and gives to the solution a yellow colour. The solution is now agitated with ether. This extracts the bromine, and the ethereal solution being specifically lighter than the liquid, it floats on its surface. The heavier saline solution is now tapped off through a separator, and the bromine solution agitated with a solution of caustic potash. The yellow colour soon disappears from the ether, and the bromine enters into combination with the potash in the aqueous solution. The ether may be separated and used over again for fresh quantities of bittern, and the potash solution can also be used for further extractions. When the latter becomes nearly saturated with bromine, it is evaporated to dryness and gently ignited. It is then mixed with peroxide of manganese. The whole is now transferred to a retort, sulphuric acid added and distilled, and the dense brown fumes of bromine condensed in receivers kept cool by ice.

Characters.—Bromine is a very dark, heavy, red liquid, and gives off dense red fumes which are extremely irritating to respiratory organs and eyes. It corrodes the skin and produces a yellow stain, and is a powerful irritant poison. It is not inflammable, neither will it support combustion. Its atomic weight is 80, and is three times as heavy as water. It boils at 145° F., and freezes at 19° F. It is soluble in cold water to the extent of about 3 per cent., and gives it a brownish red colour, the specific gravity of a saturated solution being 1.024. It is freely soluble in ether and alcohol. Bromine combines with many metals, directly producing bromides. It is an important oxidising agent, and bleaches several vegetable colours.

Uses.—Bromine is principally used as an oxidising agent, and is an indispensable reagent of the analyst.

PEROXIDE OF HYDROGEN.

Synonyms.—*Hydrogen Dioxide, Hydroxyl, Oxygenated Water,* H_2O_2.

Source. — This oxide of hydrogen was discovered by Thénard, who prepared it by decomposing the peroxides of the alkaline earths with dilute acid.

For the preparation of the pure oxide carbonic acid is most suitable. An abundant stream of the washed gas is passed through distilled water in a beaker. To this solution finely powdered barium peroxide is added from time to time in very small quantities, so that there is never any great excess present in the solution containing hydrogen peroxide, which in such case would decompose into water, with the evolution of oxygen.

After this operation has been carried on for some time, the barium carbonate is filtered off, and the solution evaporated *in* *vacuo* over sulphuric acid until the liquid assumes a syrupy consistence.

Hydrogen peroxide cannot be preserved long in this condition. In order to preserve it, it must be diluted with water, and made slightly acid with hydrochloric acid. Even in this state it gradually decomposes, especially when exposed to light. Perchloride of mercury preserves a strong solution of the peroxide.

Characters.—The most concentrated solution of hydrogen peroxide is a syrupy liquid of specific gravity 1.453, its molecular weight being 34. It does not freeze at −22° F. *In vacuo* it volatilises unchanged.

It has a harsh, bitter taste, and corrodes the skin, and is a powerful disinfectant.

Hydrogen peroxide slowly decomposes. If very dilute, it may be kept indefinitely. Very dilute solutions may be even boiled without change.

Concentrated peroxide of hydrogen rapidly evolves oxygen at 70° F. Heated quickly to 212° F., oxygen is evolved with explosion.

One volume of the most concentrated solution gives 475 volumes oxygen at 32° F. and 760 mm. Hydrogen peroxide is soluble in all proportions of water, also in alcohol; but it slowly reacts with the alcohol. Is slightly soluble in ether.

An acidified solution of hydrogen peroxide is decomposed into oxygen and hydrogen by electrolysis.

Uses.—Hydrogen peroxide is used for restoring the white colours in pictures that have turned grey or black. It is sometimes used for cloth-bleaching. Hydrogen peroxide has been used in medicine, but at present only externally. It is also the chief constituent of the "sanitas disinfectants."

SECTION VIII.

COMMON SUBSTANCES
LIABLE TO
"SPONTANEOUS" COMBUSTION.

There are substances under certain conditions which often ignite without any apparent cause; but like all other effects, this too has its cause. Many serious conflagrations have been traced to purely natural causes; and we frequently hear of the "spontaneous" combustion of coal, oily goods (waste, rags, felt, &c.), hayricks, &c., that is, they have ignited without the necessity of application of flame from any external source. The explanation of the causes of these, shall we say self-igniting fires, may be generally summarised as follows:—

Many substances have the property of absorbing or combining with the oxygen of the atmosphere at ordinary temperatures. This combination results in the production of heat, and if circumstances are favourable to rapid oxidation, the intensity of heat developed is often sufficient to inflame them or substances in immediate contact. The essential conditions necessary for the propagation of an amount of heat sufficient to bring about inflammation of a body left to itself at the ordinary temperature are:—

(1.) It should be porous, or finely divided, so as to expose a large area to oxidation.

(2.) That to prevent the dissipation of the heat of chemical action, the seat of combustion should be surrounded by a porous non-conducting body capable of inflammation, which may be the same material, such as a heap of coals, charcoal, or vegetable black; or a different material, as exemplified in a heap of oily waste, rags, or sawdust.

(3.) Access of air is in most cases necessary, but not in sufficient amount or current to carry away the heat as quickly as it is produced.

(4.) A certain degree of dampness appears to be necessary in certain cases, while moisture in some instances retards or prevents combustion.

The following are particulars regarding the more common substances liable to inflammation consequent upon rapid oxidation:—

COAL.

This well-known and indispensable combustible mineral is of vegetable origin, and is the result of the decomposition of organic matter in the carboniferous period of the geological carboniferous age, and is found in numerous localities as seams of various thicknesses and depths in the crust of the earth. The principal constituents of coal are carbon, hydrogen, oxygen, nitrogen, sulphur (present principally as iron pyrites—*disulphide of iron*), and ash. The proportions of these constituents vary greatly, depending as to how complete or otherwise the natural carbonisation of the original vegetable matter had taken place. The more complete is the change, the more carbon will be found in the coal, the less inflammable will it be, and *vice versâ.* Coal may be divided into four classes, depending upon the amount of volatile matter (gas, tar, &c.) that is given off when heated out of contact with the air. They are:—

(1.) *Cannel Coal* (parrot coal, horn coal), or highly bituminous coal, yielding over 40 per cent. of volatile matter.

(2.) *Bituminous Coal* (gas coal, house coal), yielding from 30 to 40 per cent. volatile matter.

(3.) *Semi-bituminous Coal* (steam coal), yielding from 15 to 20 per cent. volatile matter.

(4.) *Anthracite Coal*, yielding from 5 to 10 per cent. volatile matter.

The causes of the production of the heat necessary to initiate the spontaneous ignition of coal have given rise to much discussion. The heat evolved consequent upon the oxidation of the iron pyrites (disulphide of iron, brasses) present in more or less quantity in practically all coals, is generally credited with being the primary cause of the "spontaneous" conflagration in coal heaps, ships' cargoes, &c. In addition to the heat evolved during the oxidation of pyrites, the products of the oxidation disintegrates the coal, making room for the admission of more air, and thus heat is developed in the coal until the point of ignition is attained. Moisture enhances the oxidation of pyrites. Whether the presence of pyrites is absolutely necessary or not in order to produce sufficient heat conducive to the spontaneous ignition of coal heaps, there can be no doubt that in consideration of the fact of its proneness to oxidation, and that it is present in more or less quantity in all coals, the majority of cases of "*spontaneous*" combustion are attributable to it. Therefore a highly pyritic coal must be considered hazardous for storage, and as a cargo.

The Royal Commission of 1875, appointed to inquire into the question of *spontaneous* combustion in coal cargoes, reported:—

"Having completed our inquiry into the various questions embraced by the terms of the reference to us, we beg to lay before your Majesty a summary of the conclusions at which we have arrived:—

"(1.) That certain descriptions of coal are intrinsically dangerous for shipment on long voyages.

"(2.) That the breakage of coal in its transport from the pit to the ship's hold, the shipment of pyritic coal in a wet condition, and especially ventilation through the body of the coal cargoes, conduce to spontaneous combustion, even though the coal may not be unfit for conveyance on long voyages.

"(3.) That spontaneous combustion in coal cargoes would be less frequent if regard were had by shipowners and underwriters to the facts.

"(4.) That when coal is being carried on long voyages the temperature in the various portions of the cargo should be tested periodically by the thermometer and registered in the log.

"(5.) That with a view to guard against explosions, free and continuous egress to the open air, independent of the hatchways, should be provided for the explosive gases, by means of a system of surface ventilation, which would be effective in all circumstances of weather.

"(6.) That in order to make known the description of coal liable to combustion, the Inspectors of Mines should be instructed to hold inquiry into all cases of spontaneous combustion occurring in cargoes of coal taken from their respective districts; exporters being required always to record on their specifications the denomination of the coals forming the cargo.

"(7.) That no additional legislation with reference to the conveyance of coal by sea is required, unless for the purpose of giving effect to our proposals with regard to the inquiries by Inspectors of Mines, and to the fuller specification of coals entered outwards at Her Majesty's Customs."

In his work on "Spontaneous Combustion and Explosion in Coal Cargoes," Mr Rowan reviews the report of the Royal Commission of 1885 with the following conclusions:—

"That spontaneous combustion may arise from two sources—

"(1.) *Sulphurous oxidation*, or the oxidation of some of the sulphur compounds existing in the coal.

"(2.) *Carbonaceous oxidation*, or the absorption and condensation of atmospheric oxygen by the carbon pores of coal.

"Under certain conditions both of these actions arise, accompanied by the evolution of heat, and such evolutions of temperature can be induced as to result in the ignition or combustion of the coal. . . . I think it is demonstrated that in the majority of cases ignition has been inaugurated by the oxidation of the iron pyrites commencing at some particular though capricious spot, that the heat so generated has gradually accumulated and accelerated the oxidation, and that sufficient heat has been transmitted to start (it may be) carbonaceous oxidation as well; that in the confined conditions of the coal holds, where this has been taking place, the heat so produced has likewise determined, in parts of the cargo, the destructive distillation of the coal, thus evolving products of a highly inflammable and explosive nature; and those actions have often finally culminated in the cargo suddenly 'bursting out into flames all over.' This has frequently been preceded by explosions, and sometimes also followed by repeated explosions, even after all the hatches have been blown off."

CHARCOAL, BONE BLACK, LAMP BLACK, VEGETABLE BLACK.

These substances, which are so porous as to absorb and bring considerable quantities of oxygen from the air in intimate contact with them, often uniting and developing sufficient heat to cause spontaneous combustion, are essentially one and the same substance, viz., carbon. This element is a constituent of all vegetable and animal matters, from which it can be obtained commercially in various degrees of porosity and purity, and known under various names.

Charcoal.—This product is largely produced for the manufacture of gunpowder, by heating billets of wood out of contact with air, until all bituminous matters are eliminated. The resulting residue consists of a black, hard, and brittle mass of charcoal, which still retains the shape of the original wood, and which burns, when kindled in air, with practically no flame. Besides carbon, it contains a notable quantity of mineral matter, which is an essential constituent of all vegetable substances, together with smaller quantities of hydrogen and oxygen that are not perfectly eliminated during the heating.

Charcoal is extremely porous, and has the property of absorbing considerable quantities of various gases and vapours, and its absorbent powers varies according to the kind of wood from which it was produced. The charcoal produced from cocoa-nut shells appears to be the most porous kind. The following table shows the number of volumes of various gases absorbed at the ordinary temperature by one volume of charcoal made from boxwood:—

Ammonia	90
Hydrochloric acid	85
Sulphurous acid	65
Sulphuretted hydrogen	55
Carbonic acid	35
Carbonic oxide	9·4
Oxygen	9·2
Nitrogen	7·5
Hydrogen	1·75

Charcoal in sticks is less dangerous than when in powder. If charcoal be in a powder, and stored in a heap in quantities above 50 lbs., absorption of atmospheric oxygen takes place, so rapidly as to often cause spontaneous ignition; external warmth of course enhances this risk. Charcoal, if desired to be kept in any quantity, should therefore be stored in small lots in isolated and fireproof buildings.

Bone Black (*Animal Charcoal, Ivory Black*).—This substance is prepared by heating bones, hoofs, skins, &c., out of contact with air. Various gases, water, and tarry matters are eliminated, and the carbonaceous residue of bone black in the form of small grains is left in the retort, together with the mineral matter (phosphates, &c.), originally present in the bones, &c. This substance is used for decolourising and clarifying organic liquids, such as syrups, &c. When slightly damp or oily, it is very liable to ignite spontaneously.

Lamp Black.—This variety of carbon is produced from the incomplete combustion of bone oil, coal tar, &c., the smoke from which is received in suitable chambers, where the lamp black deposits in a fine state of subdivision. Formerly, it was obtained from the soot of badly trimmed oil lamps. It is used for making fine black paints. When moist or contaminated with oil, it is very liable to become heated to the point of combustion by the oxidising agency of the air. Many serious fires have resulted from the want of knowledge as to the hazardous nature of this material. It should be stored in dry metallic vessels in small quantities out of contact with air.

Vegetable Black is produced in a similar manner to lamp black, principally from oils. Frankfort black is produced from wine lees and twigs, almond and peach stones, &c., by burning and grinding to powder. It may be considered to have the same properties as lamp black.

Soot, Powdered Coal, and Coke are also similar bodies, and liable under certain conditions to become spontaneously inflammable.

OILY GOODS.

A frequent source of fires is the spontaneous ignition of various materials more or less saturated with oils or fats. The following is a list of common materials of this class, which when containing oily matter, and when under favourable conditions, will often ignite naturally:—Waste, tow, rags, sawdust, shavings, cotton and woollen cloth, roofing felt, and in fact all porous combustible bodies containing any oily or resinous substance, having an affinity for oxygen. All vegetable and animal oils have more or less affinity for oxygen, while those produced from the distillation of petroleum and shale are practically unacted upon by the element. The oils which oxidise in the air most rapidly are the vegetable drying oils, such as linseed, hempseed, poppy oil, &c. Now this gradual oxidation of oils is always accompanied with more or less heat, and if a large area of oil is exposed to the action of the air, as is the case when associated with the above-mentioned materials, oxidation proceeds so rapidly as to produce an accumulation of heat often sufficient in intensity to cause inflammation.

The chances of spontaneous ignition of oily materials in heaps or bales is greatly enhanced when under the influence of artificial heat from the sun's rays, steam or hot water pipes, boilers or flues.

The following are results of some interesting experiments conducted by Mr J. J. Coleman and Dr Young, to ascertain the time and temperature necessary that combustible fibre saturated with various oils would become spontaneously inflammable. Waste was saturated with different oils, and suspended in a chamber heated to the temperature of boiling water, and the time and temperature noted when the oleaginous material entered into combustion :—

Oil and Medium.	Entered into combustion after	At a temperature of
Cotton waste saturated with whale oil	3 hours	329° F.
Cotton waste saturated with olive oil	4 ,,	351° F.
Olive oil and 20 per cent. mineral oil	8 ,,	351° F.
Olive 50 per cent., and mineral 50 per cent.	No change after 26 hours	200° F.
Wool waste and seal oil	3 ,,	381° F.
Wool waste and whale oil	3 ,,	370° F.
Wool waste and cottonseed oil	5 ,,	352° F.
Wool waste and olive oil	7 ,,	351° F.
Wool waste and refined rape oil	6 ,,	351° F.
Wool waste and crude rape oil	8 ,,	325° F.
Wool waste and cottonseed 80, and mineral 20	No change after 26 hours.	200° F.
Jute waste with whale oil	8 ,,	356° F.
Jute waste with 50 per cent. whale and 50 per cent. mineral	No change after 26 hours	200° F.

In a chamber with a temperature varying from 130° to 170° F., the following results were obtained :—

Boiled linseed oil on cotton wool ignited in 1½ hours.
Raw ,, ,, ,, 4 ,,
Lard oil ,, ,, 4 ,,
Colza ,, ,, ,, 6 ,,
Olive ,, ,, ,, 5 ,,

Seal oil and mineral oil in equal parts on cotton would not ignite.

In a chamber heated from 180° F. to 200° F., the following results were obtained :—

Colza oil on wool	ignited in	6	hours.
Olive oil on cotton	,,	2	,,
Olive oil on wool	,,	7	,,
Seal oil on wool	,,	3	,,
Whale oil on jute	,,	9	,,
Whale oil on cotton	,,	3	,,
Cottonseed oil on wool	,,	5½	,,

The following were not ignited by twenty-four hours' exposure in the hot air chamber :—

Olive oil and mineral oil, equal parts, on cotton.
Colza oil and 20 per cent. mineral oil on wool.
Seal and mineral oil, equal parts, on wool.
Whale and mineral oil, equal parts, on jute.
Cottonseed oil and 20 per cent. mineral oil on wool.

It will be seen from the above results that the rapidity of oxidation depends not only upon the kind of oil, but also upon the nature of substance with which it is saturated, and that mineral oil (which has no affinity for oxygen), when present with fatty oils on waste, &c., either retards or prevents spontaneous ignition altogether.

Oily and dirty waste or rags of all kinds should not be allowed to accumulate in heaps on an inflammable body; but should, if necessary to be stored, be kept in metallic vessels, in corrugated iron or other sheds, away from other buildings liable to be affected by fire. If dirty and oily waste be not required for the recovery of the oil, &c., it contains, it should be burnt, preferably under boilers.

HAY.

This is an inflammable material which is frequently found ablaze brought about by heat produced resulting from the chemical action termed *fermentation*, when the hay is stored away in a damp state.

If hay or other cut grasses be properly *cured* or dried prior to storage, and kept dry, there can be no fear of ignition unless from lightning, a spark, or other external means. The heat generated in a heap of damp hay may be explained as follows :—

Organic matter in a damp state, when exposed to the air, decomposes, with the liberation of carbonic acid and other bodies. This decomposition, which is always accompanied by the development of heat, is termed *fermentation*, a process brought about by the development and sustenance of microscopical organisms upon the organic substance. Now, if there is anything fatal to the growth of fermentive micro-organisms, it is absence of water, without which the germs cannot absorb the nutriment necessary for their vital support. Hence it is that the farmer, when the weather is favourable, endeavours to get his hay thoroughly desiccated before it is raked up for stacking.

Should the hay be stacked in a damp state, fermentation would eventually develop itself. Here heat is generated, and in the centre of the stack it has no vent for dissipation, and consequently accumulates until the temperature rises sufficiently high to cause a smouldering or charring combustion. This action gradually increases until the dry hay, and some of the products of its destructive distillation produced in the immediate neighbourhood of the incipiently burning nucleus, is raised to the point of ignition, and the haystack is soon in flames. It is not only necessary to store hay in a dry state to prevent fermentation, but that it should be kept dry, since it is now generally agreed that dried or *cured* hay, on becoming again wet, can, under certain conditions, give out heat sufficient to cause spontaneous ignition.

These remarks apply also to a number of other vegetable and animal substances, when stored or conveyed in bulk, such as *Bark, Esparto, and other Grasses, Barley and Grain of all kinds, Roasted and Ground Coffee, Barley, Rice, Peas, Date-stones, Beans, and Acorns,* Rubbish heaps of all kinds containing *Vegetable and Animal Refuse, Guano.*

SPENT OXIDE.

This substance results from the purification of coal gas from sulphuretted hydrogen with peroxide of iron; the natural variety, called "bog oxide," obtained from Ireland, being that mostly used in this country for the purpose. An examination of a sample of bog oxide by the writer was found to consist of 15 per cent. organic matter, 27 per cent. of peroxide of iron, and 50 per cent. of water. In the purification of the gas, the oxide is spread in layers of about 10 inches over perforated trays, placed one above the other, in the "purifiers." The sulphuretted hydrogen present in the coal gas, on coming in contact with the oxide of iron, combines with it, forming persulphide of iron, and after it ceases to absorb any more of the gas it is taken out and oxidised in the air. By this means the sulphide of iron is reoxidised to peroxide, and free sulphur liberated, and may be again used for gas purification, and the reoxidisation repeated several times until the accumulation of free sulphur retards further absorption of sulphuretted hydrogen. The free sulphur in "spent oxide" ranges from 45 to 55 per cent. Great care should be taken that the reoxidisation takes place gradually and in a fireproof locality, because the heat given out during oxidation has often been sufficient to cause "spontaneous combustion."

FELT.

Many cases of fires resulting from spontaneous combustion of felt are on record. One case came under the writer's observation some time ago, when a fire broke out in a railway shed in which were bales of roofing felt. The felt contained a large quantity of resin; there was no external source of fire; and all the circumstances tended to show that this was a clear case of "spontaneous combustion."

A memorandum was issued by the Marine Department of the Board of Trade, in June 1885, respecting the transport of what is known in commerce as inodorous felt, in which it was stated that the attention of the Board having been called to several well-authenticated cases of spontaneous combustion occurring in the material referred to, they had caused inquiries to be made upon the subject. The particulars relating to a fire on board the S.S. "Gulf of Venice" were set out in detail as an example of the danger which is known to arise from the shipment of the material. In that case the felt was manufactured in Belfast, and sent to London by sea. It was there transhipped to the "Gulf of Venice," which vessel cleared in September 1883, *via* the Suez Canal, for Australia. The material was described at the Custom House as "felt, woollen manufactures," but on the bill of lading simply as so many cases of felt. The insufficiency of this marking is apparent, as on examination it was found that the material was made from the refuse of flax, treated with resin previously moistened with oil. Inodorous felt is generally made from these materials, but the refuse of jute is sometimes substituted for the refuse of flax, and various descriptions of oil (including paraffin) are used.

The following is an account of the fire, extracted from the official log book:—"On the 15th October 1883, the vessel being in the Indian Ocean, the chief officer reported that smoke was coming out of the forward ventilator on starboard side in No. 1 'tween decks. At once directed the hatches to be taken off, and had the fire hose played in the part of the hold where the body of the smoke was most dense. After a few minutes, finding it had the desired effect, stopped playing water in the hold, and began taking the cargo on deck. After a short time came on the burning portion of the cargo, which was a bale of felt, and it was on fire right in the middle of one of the bolts of felt in a case. Had it removed on deck and thrown overboard. Examined the other cargo around it, but found no more heated. Had all that had been wet with the hose brought on deck to dry. They were all more or less cut with hooks while being got on deck before the burning bale was got at. On the 17th October, while examining the fore hold where the fire had been on the 15th, found another bale of same mark as that on fire before very much heated and commencing to let out smoke. Brought it on deck, with six more of the same quality, and having cut them open, found them greatly heated over 210°. Deeming them not safe to again stow with any other cargo, had them all hove overboard. On the 24th October 1883 found that fire had again broken out in fore hold No. 1. Got the cargo on deck from the lower hold and got at the cause of the fire—a bale of felt. Got it on deck and hove it overboard. Stowed cargo on deck, and covered it over with sails."

It is to be noted that no claim was made for the non-delivery of the shipment either in Australia or in the United Kingdom.

The master, previously to throwing the felt overboard, cut samples from the burning bales, portions of which came into the possession of the Board of Trade, and were submitted to experts connected with the felt trade, all of whom expressed the opinion that it was a dangerous material to ship, and very liable to spontaneous combustion.

At a special meeting of the Feltmakers' Association, held in London on 18th January, attention was called to the frequent occurrence of spontaneous combustion in inodorous felt on board ship, and the following resolutions were unanimously adopted:—

(1.) "That inasmuch as inodorous felt is liable to spontaneous combustion, in future no inodorous felt be shipped to foreign ports."

(2.) "That the following notice shall be placed on all letters relative to inodorous felt for shipment abroad: 'Inodorous felt, being liable to spontaneous combustion, should not be shipped for transmission abroad, but if you wish to do so, please see the Merchant Shipping Act of 1873, Sections 23 and 24.' This notice to be printed in red and pasted on the invoice of all orders, where there is the slightest suspicion that it is intended for transmission abroad"

It was also subsequently agreed to prominently mark on each frame the words "inodorous felt" in red letters 1¾ inches long.

The memorandum pointed out, however, that inodorous felt should not be confounded with tarred roofing and sheathing felts, which (so far, it was said, as the Board of Trade had been able to ascertain) are not liable to spontaneous combustion. Inodorous felt, although used as a roofing felt, can generally be distinguished from other kinds by its lighter colour; and if the precautions in marking, which the Feltmakers' Association have agreed to adopt, be observed, it was hoped by the Board that cases of fire originating in this article on board ship might for the future be avoided.

The Board of Trade have also issued the following instructions to Detaining and Emigration Officers at the several ports to the transport of inodorous felt:—"It should on no account be treated as general cargo, and covered with other goods. Emigration Officers should not allow inodorous felt to be loaded on board passenger ships (see Section 29 of the Passengers Act, 1855), and in the event of the material being in any case shipped in such a manner as, in the opinion of a Detaining Officer, to render a ship unfit to proceed to sea without serious danger to human life, he should not hesitate to order provisional detention, if necessary, under Section 6 of the Merchant Shipping Act, 1876, referring to the Board of Trade if he is in doubt or difficulty."

SECTION IX.

EXPLOSIVES.

An explosive is a body which, under favourable conditions necessary for its decomposition (or combination), can give rise to a sudden increase in pressure in surrounding air or gases, consequent upon the violent and sudden expansion of the products of such decomposition (or combination). The "Explosives Act, 1875," defines the term "explosives" as follows:—

(1.) "Means gunpowder, nitro-glycerine, dynamite, gun-cotton, blasting powders, fulminate of mercury, or other metals, coloured fires, and every other substance, whether similar to those above mentioned or not, used or manufactured with a view to produce a practical effect by explosion or a pyrotechnic effect; and

(2.) "Includes fog signals, fireworks, fuses, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, and every adaptation or preparation of an explosive as above defined."

In popular language, explosives are classified into "high" and "low," which may be represented by the prototypes dynamite and gunpowder respectively.

The classification of explosives referred to in the Bye-laws, on page 291, as contained in an Order of Council, dated 5th August 1875, is divided into eight classes, each class being somewhat similar in composition and general properties, although known under a great variety of fancy names. The following are the titles of the eight classifications recognised by the Government :—

Class I.—Gunpowder class.
Class II.—Nitrate-mixture class.
Class III.—Nitro-compound class.
Class IV.—Chlorate-mixture class.
Class V.—Fulminate class.
Class VI.—Ammunition class.
Class VII.—Firework class.

We shall now give a description of each of the classes as to properties, composition, &c., with the definitions as contained in the said Order of Council :—

I.—GUNPOWDER CLASS.

The term "gunpowder" means exclusively gunpowder ordinarily so called.

Gunpowder is a mechanical mixture of nitre, charcoal, and sulphur. Good charcoal obtained from dogwood, willow, or alder, is the best for the purpose; the sulphur preferred is that which has been distilled and ground to a fine meal; and nitre only of the first quality is employed.

The proportion of these ingredients varies in different countries, and also according to the purpose for which the gunpowder is proposed to be used.

The following table shows the percentage compositions of gunpowders of various countries :—

	Nitre.	Sulphur.	Charcoal.
English and Austrian (musket) - - -	75	10	15
Prussian (musket) - - - - -	75	11.5	13.5
Swedish (musket) - - - - -	75	9	16
Chinese - - - - - - -	75.7	9.9	14.4
French (musket) - - - - -	75.0	12.5	12.5
,, (sporting) - - - - -	76.9	9.6	13.5
,, (blasting) - - - - -	62	20	18

The products of combustion of gunpowder are very complicated, the composition varying according to the manner in which the powder is fired. Karolyi, Nobel, and Abel succeeded in making an analysis of the products of combustion of gunpowder.

The following shows some of the results obtained by firing three kinds of powder under the conditions of artillery practice :—

(1.) COMPOSITION OF THE POWDER USED.

		Ordnance Powder.		Small Arms Powder.		Pebble Powder (Noble and Abel).	
Nitre		73.78		77.15		74.67	
Sulphur		12.80		8.63		10.07	
Charcoal	Carbon	10.88	13.39	11.78	14.27	12.12	14.22
	Hydrogen	0.38		0.42		0.42	
	Oxygen	1.82		1.79		1.45	
	Ash	0.31		0.28		0.23	
Water		...		...		0.95	
		99.97		100.05		99.91	

(2.) PRODUCTS OF COMBUSTION OF 100 PARTS BY WEIGHT.

	Ordnance Powder.	Small Arms Powder.	Pebble Powder (Noble and Abel).
Nitrogen	9.77	10.06	11.39
Carbonic Acid	17.39	21.79	27.70
Carbonic Oxide	2.64	1.47	4.73
Hydrogen	0.11	0.14	0.05
Sulph. Hydrogen	0.27	0.23	0.84
Marsh Gas	0.40	0.49	0.12
Total Gaseous	30.58	34.18	44.83
Ammonic Sesquicarbonate	2.68	2.66	0.04
Potassic Sulphate	36.95	36.17	6.58
,, Carbonate	19.40	20.78	30.98
,, Thiosulphate	2.85	1.77	3.38
,, Sulphide	0.11	...	10.55
Charcoal	2.57	2.60	...
Sulphur	4.69	1.16	3.40
Loss	0.17	0.68	...
Potassic Sulphocyanate	...	...	0.13
,, Nitrate	...	...	0.11
Total Solid	69.42	65.82	55.17

(3.) PRODUCTS OF COMBUSTION BY VOLUME IN 100 OF GAS.

	Ordnance Powder.	Small Arms Powder.	Pebble Powder (Noble and Abel).
Nitrogen - - -	37.58	35.33	32.19
Carbonic Acid - -	42.74	48.90	49.82
Carbonic Oxide -	10.19	5.18	13.36
Hydrogen - -	5.93	6.90	2.08
Sulphuretted Hydrogen	0.86	0.67	1.96
Marsh Gas - -	2.70	3.02	0.58
	100.00	100.00	99.99

II.—NITRATE-MIXTURE CLASS.

The term "nitrate-mixture" means any preparation, other than gunpowder ordinarily so called, formed by the mechanical mixture of a nitrate with any form of carbon or with any carbonaceous substance not possessed of explosive properties, whether sulphur be or be not added to such preparation, and whether such preparation be or be not mechanically mixed with any other non-explosive substance.

The nitrate-mixture class comprises such explosives as Pyrolithe, Pudrolithe, Poudre Saxifragine, and any preparation coming within the above definition.

The principal difference in the composition of these powders to ordinary gunpowder is the substitution of a part or whole of the nitrate of potash by other nitrates, such as those of sodium, ammonium, and barium. Nitrate of sodium and ammonium are rather deliquescent salts, and powder made from them would soon get damp when used in the same manner as ordinary powder in such climates as England. In tropical climates there would be some advantage in their use, sodium nitrate being considerably cheaper than potassium nitrate; and it is stated that powder made with sodium nitrate is about one-third stronger than when produced from nitrate of potassium.

The following is a list of names of the various powders coming under this class:—

Aix-la-Chapelle Powder.
Amide Powder.
Azontine.
Bennett's Powder.
Bleckmann's Powder (also called Haloxyline).

Bolton's Powder.
Brandeisl's Powder.
Courtreille's Powder (also called Triumph Safety Powder).
Davey's Powder.
De Terré's Powders.
De Tret's Powder (also known as Pyronome).
Dieckerhoff's Powder.
Diorrexin.
Eaton's Powder.
Eisler's Powder.
Espir's Powder.
Freiberg Powder.
Gaeon's Powder (Grenadine).
Gallahir's Powder.
Gemperlé.
Glycero-nitre (also known as Fortis).
Fortis.
Fortisine (originally termed Fortis 3 and 4).
Haloxyline.
Hardy's Powder.
Harrison's Powder.
Heraklin.
Johnite (also called Jahnit).
Küps.
Lederit.
Liesch's Powder (also called Petralit).
Lithofracteur.
Lobb's Powder.
Maxim's Powder.
Miller's Powder.
Murtineddu's Powders.
Nobel's Powder.
Oliver's Powder.
Oriental Powder.
Oxland's Powder.
Petralite.
Pudrolithe or Rock Powder.
Pyrolithe.
Pyronome.
Pyronitrine.
Roberts' Powder.
Rock Powder (Pudrolithe).
Robandis Powder (Brise-roes).
Safety Blasting Powder (Carbo-azotine).
Saxifragine.
Schäffer's Powders.
Soulages.
Starch Powder.
Sulphurite.
Violette's Powder.
Vulcanite.
Wetzler Powder.
Windsor's Powder.
Wynont's Powder.
Xanthine Powder.

The majority of these powders do not get beyond the Patent Office and the experimental stage. The following is a list of the more notable varieties of this class, showing their compositions:—

"Amide Powder."

Saltpetre - -	- 101 parts.
Nitrate of Ammonia	- 80 ,,
Charcoal - -	- 40 ,,

"Bennett's Powder."

Saltpetre - -	- 65 parts.
Sulphur - -	- 10 ,,
Charcoal - -	- 18 ,,
Lime - - -	- 7 ,,

"Bolton's Powder."

Carbonate of Copper	8 parts.
Graphite	10 ,,
Prepared Quicklime	14 ,,
,, Alum	50 ,,
,, Sugar	350 ,,
Nitrate of Soda	350 parts.
Soda Ash	20 ,,
Ferrocyanide of Potassium	300 ,,
Charcoal	30 ,,
Carbonate of Potash	450 ,,

"Courtreille's Powder" (Triumph Safety Powder).

Nitrate of Soda or Potash	60 to 75 parts.
Sulphur	10 to 12 ,,
Charcoal	7 to 10 ,,
Peat and Hard Coal	9 to 12 ,,
"Combined Metallic Sulphate"	2 to 4 ,,
Oleaginous Matter, animal or vegetable (or tar), refined or crude	1 to 3 ,,

"Brandeisl's Powder."

Saltpetre	16 parts.
Sulphur	2 ,,
Sugar	3 ,,

"Davey's Powder."

Saltpetre	64 parts.
Sulphur	16 ,,
Charcoal	12 ,,
Fluor, Bran, or Starch	8 ,,

"Pyronome."

Nitrate of Soda	52.5 parts.
Spent Tan	27.5 ,,
Sulphur	20.0 ,,

"Espir's Powder."

Nitrate of Soda	60 parts.
Sulphur	14 ,,
Sawdust	26 ,,

"Diorrexin."

	A.	B.
Nitrate of Potash and Soda	75	60
Sulphur	12	12
Sawdust	13	10
Charcoal	...	7
Picric	...	1.5
Moisture	...	7.5

"Eisler's Powder."

Nitrate of Soda	70.1 parts.
Sulphur	17.6 ,,
Charcoal	12.25 ,,
Sugar	1.2 ,,
Ashes	1.2 ,,
Moisture	0.83 ,,

Fortis or Glycero-Nitre.

	1	2	3	4	5	6	7	8	9
Nitrate of Potash -	65.01	66.02	67.03	68.04	69.05	70.06	72.08	74.10	93.19
Sulphur -	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Lampbl'k	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Tan - -	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	25.00
Sulphate of Iron -	1.39	2.78	4.17	5.56	6.95	8.34	11.12	13.90	27.8
Glycerine	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	1.84
	102.32	104.72	107.12	109.52	111.92	114.32	119.12	123.92	162.83

The first five materials are powdered, wetted, and evaporated nearly to dryness; it is then completely dried, cooled, and the glycerine added to it. It is a black powder, and it is claimed that the various forms of nitro-glycerine are produced in the act of explosion in a blast hole. Licenses are granted for the manufacture and use of this explosive under certain conditions.

Harrison's Powder.

Saccharum (saccharine matter) - - - - - - -	50 parts.
Saltpetre - - - - - - - - - -	48 ,,
Club Moss (*Lycopodium clavatum*) - - - - - -	2 ,,

Johnite.

Nitrate of Potash - -	75 parts.
Sulphur - - -	10 ,,
Lignite - - - -	10 ,,
Picrate of Soda - -	3 ,,
Chlorate of Potash -	2 ,,

Petralite.

Saltpetre - - -	63 parts.
Charcoal - - -	30 ,,
Sulphide of Antimony -	6 ,,

Murtineddu's Powder.

Saltpetre - - -	100 parts.
Sulphur - - - -	100 ,,
Sawdust - - -	50 ,,
Horse Dung - - -	50 ,,
Sea Salt - - -	10 ,,
Treacle - - - -	4 ,,

Pudrolithe.

Saltpetre - - -		68 parts.
Sulphur - 12 parts	Sulphur	8 ,,
or	Gumlac	3 ,,
Charcoal - - -		6 ,,
Nitrate of Baryta - -		3 ,,
Nitrate of Soda -		3 ,,
Sawdust - - -		5 ,,
Spent Tan - - -		3 ,,

Pyronitrine.

	1	2
Nitrate of Soda	35	18
Saltpetre	35	45
Tan	15	15
"Sulphate"	2	3
Sulphur	6	9
Charcoal	3	—
Resin	4	3
Tar	—	7

Safety Blasting Powder (Carbo-azotine).

Nitrate of Potash ,, Soda ,, Lime	one, two, or three Nitrates	in all 50 to 64 parts.
Sulphur		13 to 16 ,,
Tanner's Bark (that containing refuse animal matter is preferred), or		14 to 16 ,,
Sawdust, or		
Bark and Sawdust		
Soot or Lampblack or both		9 to 18 ,,

Saxifragine.

Nitrate of Baryta	77 parts.
Charcoal	21 ,,
Saltpetre	2 ,,

Sulphurite.

Saltpetre	62 parts.
Sulphur	30 ,,
Charcoal	4 ,,
Wood Ashes	4 ,,

Xanthine Powder.

Saltpetre	100 parts.
Xanthate	40 ,,
Charcoal	6 ,,

Schaffer's Powder.

Potassio-Tartrate of Soda	4 parts.
Saltpetre	78 ,,
Sulphur	8 ,,
Charcoal	10 ,,

Vulcanite.

Nitrate of Potash	35 parts.
Nitrate of Soda	19 ,,
Sulphur	11 ,,
Sawdust	9·5 ,,
Chlorate of Potash	9·5 ,,
Charcoal	6 ,,
Sulphate of Soda	2¼ ,,
Sugar	2¼ ,,
Picric Acid	1¼ ,,

III.—NITRO-COMPOUND CLASS.

The term "nitro-compound" means any chemical compound possessed of explosive properties, or capable of combining with metals to form an explosive compound, which is produced by the chemical action of nitric acid (whether mixed or not with sulphuric acid), or of a nitrate mixed with sulphuric acid upon any carbonaceous substance, whether such compound is mechanically mixed with other substances or not.

The nitro-compound class has two divisions.

Division 1 comprises such explosives as—

Nitro-glycerine,
Dynamite,
Lithofracteur,
Dualine,
Glyoxiline,
Methylic Nitrate,

and any chemical compound or mechanically mixed preparation which consists either wholly or partly of nitro-glycerine or of some other liquid nitro-compound.

Division 2 comprises such explosives as—

Gun-cotton, ordinarily so called,
Gun-paper,
Xyloidine,
Nitrated gun-cotton,
Cotton Gunpowder and Cotton Powder,
Schultz's Powder,
Nitro-mannite,
Picrates,
Picric Powder,

and any nitro-compound, as before defined, which is not comprised in the first division.

The following are characters, &c., of the more important representatives of this class:—

Nitro-Glycerine, $C_3H_5(NO_3)_3$.

This substance, which is the acting constituent of the important class of explosives generally termed "dynamites," is prepared on a large scale by first mixing 4 parts of strong sulphuric acid and 1 part of fuming nitric acid in a wooden vessel lined with lead, and allowing to cool, after which 1 part of glycerine is allowed to run into the mixture in a thin stream. The whole is agitated with compressed air and kept cool with cold water, which runs through leaden worms contained in the nitrating vessel. The temperature of nitration should not exceed 77° F. On allowing to stand for some time, the nitro-glycerine separates as an oily liquid on the surface of the acid, which is separated, washed first with water, and finally with a dilute solution of sodic carbonate to eliminate the last traces of acids. The sulphuric acid takes no part in the reaction beyond keeping the nitric acid up to the proper strength by combining with the water produced in the process.

It is important that all free acid should be perfectly neutralised, since, if any is left in the finished product, it is liable to spontaneously decompose. The specific gravity of nitro-glycerine is 1.600 at 60° F., and it solidifies at 46° F. When heated to about 495° F., it decomposes with a sharp detonation. A similar result is obtained when a little of the substance is smartly struck or compressed. When ignited in air, it burns with a greenish flame without explosion. When completely exploded, the products of combustion are carbonic acid, nitrogen, water, and free oxygen.

The Glycerine used.—It is very essential that the quality of the glycerine used in the manufacture of nitro-glycerine should be of the best. The minimum specific gravity should be 1.261 at 15° C., and must be free from lime, iron, alumina, chlorides, and fatty acids. Not more than 0.25 per cent. of inorganic and organic matter should be left when 25 grams of the sample are evaporated in a weighed platinum dish and the residue dried in an air bath at 320° F., until the weight remains constant. The residue may be incinerated, and the amount of inorganic matter present thus estimated.

A good test of the quality of glycerine is to measure the proportion of nitro-glycerine yield on nitration. Theoretically, 1 lb. of glycerine should yield 2.47 lbs. of nitro-glycerine, but on the manufacturing scale only about 2 lbs. are produced, due to unavoidable waste and the formation of other nitro-compounds which are carried away with the washings.

Dynamite.

Dynamite is usually a plastic body varying in colour from brown to reddish brown, and is prepared by mixing nitro-glycerine with a highly porous substance such as kieselguhr, largely composed of silica.

Dynamite is sent out in cylindrical rolls of a thickness suitable to the size of bore-holes required, and covered with parchment paper so as to form cartridges. Packets of 5 lbs. of cartridges are made, and ten of these packages go to a box.

Explosives of the dynamite class become hard or frozen when exposed to cold, about 40° F. being the usual freezing point, but they still remain frozen when warmed considerably above this point. In this condition dynamite is of no use for blasting purposes unless first thawed. Frozen dynamite is much less sensitive to a blow or detonation than it is in the unfrozen state, and on ignition it is very liable to explode, which is not the case with unfrozen dynamite, the latter burning away without explosion. Great care should be exercised in the thawing of frozen dynamite cartridges, since there have been a great number of fatal accidents brought about by warming the cartridges before a fire, &c., and by methods of which no gauge of temperature can be obtained. It will appear obvious, when it is considered how explosive nitro-glycerine compounds become when they are heated near their points of explosion, viz., 360° F., that such methods of thawing are highly dangerous.

A safe method of thawing is to employ an apparatus of the glue-pot principle. Hot water at a temperature of about 140° F. is poured into the outer vessel, then the dry inner pot containing the cartridge is allowed to digest in it until the latter has attained its normal condition.

There are two varieties of dynamite licensed in this country, known as Dynamite No. 1 and Dynamite No. 2, the latter being a slower and milder variety than the former. The following are their legal definitions:—

"*Dynamite No.* 1, consisting of not more than 75 parts by weight of thoroughly purified nitro-glycerine, uniformly with 25 parts by weight of—

"(*a.*) An infusorial earth known as *kieselguhr*, or "(*b*.) A non-explosive mixture of kieselguhr with such other ingredients and in such proportions as may for the time being be sanctioned by the Secretary of State.

"Provided—

"(1.) That the said *kieselguhr*, or (*b*) non-explosive mixture, shall be sufficiently absorbent in quality when mixed in the above proportions to prevent exudation of nitro-glycerine; and

"(2.) That there may be added to the kieselguhr or non-explosive mixture an amount of carbonate of ammonium not exceeding $1\frac{1}{2}$ parts by weight in every 100 parts by weight of finished dynamite."

The ingredients at present sanctioned under (*b*) are:—

Carbonate of sodium -	In all 8 parts (or less) by weight, in substitution for an equal amount by weight of kieselguhr.
Sulphate of barium -	
Mica - - - -	
Talc - - - -	
Ochre - - - -	

Provided that the total amount of carbonate of sodium shall in no case exceed 3 parts by weight in every 100 parts by weight of the finished dynamite.

"*Dynamite No.* 2, consisting of not more than 18 parts by weight of thoroughly purified nitro-glycerine, uniformly mixed with 82 parts by weight of a pulverised preparation, composed of nitrate of potassium 71 parts, charcoal not less than 10 parts, and purified paraffin (or ozokerit) 1 part (or nitrate of potassium 72 parts, and charcoal not less than 10 parts) by weight, and sufficiently absorbent in quality when mixed in the above proportions to prevent exudation of nitro-glycerine."

There are numerous explosives of the dynamite class now in the market, containing a variety of substances, many of which are not classified among the explosives licensed in this country. For the composition of various kinds, *see* pages 147-150.

Gun-Cotton.

This important explosive, which is also known as nitro-cellulose, and characteristic of the explosives of this division, is manufactured upon a similar principle to nitro-glycerine from clean and dry cotton wool or cellulose by the action of a mixture of 3 parts by weight of sulphuric acid, specific gravity 1.84, to 1 of nitric acid, specific gravity 1.52. The nitrated product thus produced is then washed till free from acid, after which it is pulped and compressed into any form required. Theoretically 100 parts by weight of cellulose produces 218.4 parts of gun-cotton. Gun-cotton can be thoroughly soaked with water, in which state it is not inflammable, but will explode when fired with dry gun-cotton started with a detonator. Gun-cotton has somewhat similar properties to nitro-glycerine when burned or exposed to blows or shocks; also in respect to explosion and detonation. It is a most powerful explosive, and is extensively used for military and blasting purposes.

A solution of gun-cotton in ether and alcohol is called *collodion*—a photographer's requisite. It is also a constituent of the highly inflammable bodies known as *Celluloid*, *Xylonite*, *and Xyrolene.*

Picric Acid.

Synonyms.—*Trinitrophenol*, $C_6H_2(NO_2)_3OH$.

Source.—Picric acid is obtained from carbolic acid or phenol by the action of nitric acid upon it. On the commercial scale the carbolic acid is first converted into phenol-sulphonic acid by heating it to 212° F. with an equal part of concentrated sulphuric acid. Nitric acid, of specific gravity 1.3, is then run in, after which the product is filtered and washed with cold water.

Characters.—Picric acid crystallises in pale yellow shining scales which melt at 253° F. It is practically insoluble in cold water, but is soluble in hot water and ether. When gently heated it sublimes unchanged, but when heated more strongly it explodes. It has an acid reaction and a bitter taste, and gives the skin a yellow stain, and is poisonous; a couple of grains being sufficient to poison a dog. It forms yellow crystalline unstable salts called picrates, which are explosive.

Uses.—Picric acid and the picrates of potash and lead enter into the composition of a class of explosives known as picrate powders. Picric acid is used as a dye for silk, wool, and leather, and a minute quantity is sometimes mixed with malt liquors to give them a bitter taste.

The following is a list of the explosives which come under this class:—

Division I.

Ætna Powder.
Americanite.
Ammonia dynamite (Ammoniak-krut).
Ammonia Gelatine.
Arlberg Dynamite.
Asbestos Powder.
Atlas Powder.
Ballistite.
Blasting Gelatine.
Brain's Powders.
Burstenhender's Powder.
Camphorated Gelatine.
Carbo-Dynamite.
Castellanos Powders.
Champion Powder.
Clark's Explosive (Glycero-Pyroxiline).
Coad's Explosive.
Colonia Powder.
Dean's Explosive.
Diaspon-Gelatin.
Diaspon.
Dualine.
Dynamite No. 1.
Dynamite No. 2.
Dynamite au Charbon.
Dynamite Blanch de Paulilles.
Dynamite de Boghead.
Dynamite E.C.
Dynamite Grises de Paulilles.
Dynamite de Krümmel.
Dynamite Noire.
Dynamite Rouge.
Dynamite S.T.
Dynamite de Vonges.
Engel's Powder.
Extra Powder.
Extra Dynamite.
Foreite.
Fowler's Explosive.
Fulgurite.
Fulminatine.
Gelatine Dynamite (Gelignite).
Giant Powder.
Glukodine.
Glyoxiline.
Gotham's Explosive.
Hecla Powder.
Hercules Powder.
Hill's Powder.
Hinde's Powder.
Horsley's Powder.
Judson's Dynamite.
Judson's Powder.
Jupiter Powder.
Kraft.
Lignin Dynamite (Lignose).
Lithofracteur.
Matagnite (Blasting).

Matagnite Gelatine.
Mataziette.
Meganite.
Metalline Nitroleum.
Mica Powder.
Miner's Friend Powder.
Miner's Powder Company Dynamite.
Monukay's Explosive.
Morse's Explosive.
Neptune Powder.
Nitro-Glycerine.
Nitrolite.
Nitro-Magnite or Dyna-Magnite.
Nobel Powders.
Norrbin.
Oriasite.
Paleine.
Petralithe.
Porifera Nitroleum.
Pontentia.
Punshon's Explosive.
Rendroek.
Rhenish Dynamite Co.'s Powders.
Rhexite.
Rutenberg's Explosive.
Safety Dynamite.
Safety Nitro-Powder.
Schultze's Powder.
Sebastine.
Selenitic Powder.
Seranine.
Straw Dynamite.
Thunderbolt Powder.
Thunder Powder.
Titan Powder.
Trouzl's Dynamite.
Vigorite.
Virite.
Vulcan Powder.
Waffen's Dynamite.
Warren's Powder.
Warren's Dynamite.
Welter Dynamite.
White Dynamite (Diller).

Division II.

Ammonia Nitrate Powder.
Aeapina.
Ammonite.
Audemars.
Bantoek's Powders.
Barnwell's Powder.
Bautzen Powder.
Bellite.
Bjorkmann's Powder.
Carbonite.
Clark's Powder.
Cooppal's Powder.
Cotton Powder (Tonite).
Cordite.
Davey's Powder.
E.C. Powders.
Emilite.
Extralite.
Favier's Explosive.
Gathurst Powder.
Gun-Cotton.
Grakrult.
Hengstite.
Johnson's Powders.
Keil's Explosive.
Kinetite.
Lanfrey's Powder.
Lannoy Powder.
Lightning Powder.
Nitramidine.
Nitrated Gun-Cotton.
Nitro-Molasses.
Nitro-Naphthalene.
Nitro-Peat.
Nitro-Saccharose.
Nitro-Starch (*Xyloidine and Pyroxylam*).
Nitro-Tar.
Nitro-Toluole.
Paleina.

Papier Fulminant.
Patent Gunpowder.
Petragit.
Petralite.
Petrofracteur.
Plera.
Potentine.
Prentice.
Punshon's Gun-Cotton.
Pyropapier.
Rifle Gun-Cotton.
Roburite.
Romit.
Sawdust Gunpowder.
Schultze Gunpowder.
Schultze Blasting Powder.
Securite.
Smokeless Powders.
Titan Powder.
Tonite or Cotton Powder.
Vigorite.
Volney's Powder.
Wahlenberg's Powder.
Wood Gunpowder.
Xyloglodine.

The Picric Powders of Division II.

Borlinetto's Powder.
Bronolith.
Designolle's Powders.
Eclipse.
Emmensite.
Fontaine's.
Howitite.
Lithotrite.
Melinite.
Oxonite.
Picrate of Potash.
Picric Powder.
Tschirner's Powder.
Victorite.

The following is a list showing the composition of the more important powders of this class:—

Division I.

Ammonia Gelatine

Consists of 40 parts of a thin blasting gelatine (*q.v.*), containing 97.5 parts of nitro-glycerine to 2.5 of nitro-cotton, incorporated with 55 parts of nitrate of ammonia and 5 parts of charcoal.

Atlas Powder.

	A.	B.
Sodium Nitrate - - -	2	34
Wood Fibre - - -	21	14
Magnesium Carbonate -	2	2
Nitro-Glycerine - - -	75	50

Ballistite

Is licensed as consisting of nitro-cotton combined with thoroughly purified nitro-glycerine, with or without the addition of camphor or aniline in such proportions that the whole shall be of such character and consistency as not to be liable to exudation or liquefaction.

Blasting Gelatine.

Two varieties are licensed, viz., No. 1, which is defined as "nitro-cotton (purified nitro cellulose), combined with thoroughly purified nitro-glycerine in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation." No. 2 is merely No. 1, with the addition of a nitrate with or without charcoal. No. 1, which is generally used, and contains from 93 to 95 per cent. of nitro-glycerine, is issued, like dynamite, in cartridges. It is practically unaffected by water, and is not so prone to freeze as dynamite.

Camphorated Gelatine.

This is a special mixture of blasting gelatine and camphor.

Coad's Explosive.

	1.	2.	3.
Nitro-Glycerine - -	75	30	30
Saltpetre - - -	5	50	—
Naturally Decayed Wood	20	20	10
Ordinary Blasting Powder	—	—	60

Dualine.

Nitro-Glycerine - -	50 parts.
Fine Sawdust - -	30 ,,
Saltpetre - - -	20 ,,

Castellanos Powders.

Nitro-Glycerine - -	40 parts.
Nitrate of Potash or Soda	25 ,,
Picrate - - - -	10 ,,
Sulphur - - -	5 ,,
Insoluble Salts - -	10 ,,
Carbon - - - -	10 ,,

Dynamite.

(*See* page 141.)

EXTRA DYNAMITE.

Nitro-Glycerine - -	48.4 parts.
Nitro-Cotton - -	1.6 ,,
Nitrate of Ammonia -	34.5 ,,
Nitrate of Soda - -	5.0 ,,
Rye Flour - - -	9.0 ,,
Soda - - - -	1.0 ,,
Ochre - - -	0.5 ,,

Forcite.

This explosive is now defined as consisting of thoroughly purified nitro-glycerine, thickened by being combined with nitro cotton, and mixed or incorporated with wood meal and nitrate of potassium in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation. It is simply a gelatine dynamite.

Gelatine Dynamite.

This explosive is an intermediate between blasting gelatine and dynamite. It consists of a thin blasting gelatine mixed with other substances. Two varieties are licensed. No. 1 contains cotton, charcoal, or "such other ingredients as may for the time being be sanctioned by a Secretary of State." No. 2 consists of No. 1 mixed or incorporated with nitrate of potash or other nitrates. The varieties practically in use contain nitro-glycerine, nitro-cotton, nitrate of potash and wood meal. They resemble blasting gelatine very closely in appearance, and it requires practice to distinguish them apart. Both come under No. 2 class, and differ in grade only. One contains about 80, the other 60 per cent. of explosive. The latter is known as *Gelignite.*

Glukodine.

This is a liquid explosive prepared by the nitration of a saturated solution of cane sugar in glycerine.

Kraft.

Nitro-Glycerine - -	62 parts.
Chlorate of Potash - -	19 ,,
Nitrate of Potash - -	17 ,,
Ground Cork - - -	14 ,,

Rendrock.

Nitrate of Potash - -	40 parts.
Nitro-Glycerine - -	40 ,,
Wood Fibre - - -	13 ,,
Paraffin or Pitch - -	7 ,,

Vulcan Powder.

Nitro-Glycerine - -	30 parts.
Nitrate of Soda - -	52.5 ,,
Sulphur - - - -	7 ,,
Charcoal - - -	10.5 ,,

White Dynamite.

Nitro-Glycerine - -	70 parts.
Limestone "Guhr" -	19.35 ,,
Wood Pulp - - -	10.65 ,,

The limestone "guhr" is a calc tuff found in stalactitic caverns, &c.

Hercules Powder.

	No. 1.	No. 2.
Carbonate of Magnesia	20.85	10.00
Nitrate of Potash -	2.10	31.00
Chlorate of Potash -	1.05	3.34
White Sugar - -	1.00	15.66
Nitro-Glycerine - -	75.00	40.00

Lithofracteur.

	A.	B.
Nitro-Glycerine - -	52	70
Kieselguhr and Sand -	30	23
Powdered Coal - -	12	2
Nitrate of Soda - -	4	—
Nitrate of Baryta - -	—	5
Sulphur - - - -	2	—

Vigorite.

Nitro-Glycerine	30 parts.
Nitrate of Soda	60 ,,
Charcoal	5 ,,
Sawdust (or partly nitrated Wood or Paper Pulp)	5 ,,

Waffen's Dynamite.

Sodium Nitrate	22.50	60 parts.
Decayed Wood	36.00	
Picric Acid	0.25	
Sulphur	1.00	
Sodium Carbonate	0.25	

And 40 parts of

Nitro-Glycerine	94.0
Collodion	6.0

Division II.

Ammonia-Nitrate Powder

Ammonium Nitrate	80 parts.
Potassium Chlorate	5 ,,
Nitro-Glucose	10 ,,
Coal Tar	5 ,,

E.C. Powders.

Nitro-Cellulose, soluble	27.95 parts.
,, insoluble	28.35 ,,
Cellulose (unconverted)	3.15 ,,
Nitrates of Potassium and Barium	37.80 ,,

Johnson's Powders.

	For Military Arms.	For Sporting Arms.
Nitro-Cellulose	50 parts.	50 parts.
Potassium Nitrate	40 ,,	22 ,,
Barium Nitrate	—	25 ,,
Torrefied Starch or Lampblack	10 ,,	3 ,,

Carbonite.

This explosive is now licensed as follows :—

"Carbonite consisting of not more than 25 parts by weight of thoroughly purified nitro-glycerine, with or without the addition of not more than half a part of sulphuretted benzole, uniformly mixed with 75 parts by weight of a pulverised preparation consisting of wood meal not less than 40 parts ; nitrate of potassium and nitrate of sodium (either of them) not more than 34 parts ; and carbonate of sodium not more than half a part, such preparation to be sufficiently absorbent when mixed in the above proportions to prevent exudation of nitro-glycerine."

Nitro-Molasses.

This explosive is prepared by nitrating 380 parts molasses with 1000 parts fuming nitric acid, and 2000 parts of concentrated sulphuric acid.

Petrofracteur.

Nitro-Benzene	10 parts.
Chlorate of Potash	67 ,,
Nitrate of Potash	20 ,,
Sulphide of Antimony	3 ,,

Nitro-Naphthalene.

Nitro-Naphthalene	10 parts.
Saltpetre	75 ,,
Charcoal	12½ ,,
Sulphur	12½ ,,

Petralite.

Nitrate of Potash or Soda	64 parts
Nitrated Wood or Charcoal	30 ,,
Ammonium Carbonate	6 ,,

Petragit.

Nitrated Molasses	38.6 parts.
Nitrated Wood Meal	5 ,,
Saltpetre	56.4 ,,

Roburite.

This explosive, which is now somewhat extensively used in coal-mining operations, is a mixture of nitrate of ammonium with chlorinated di-nitro-benzole, and is similar to *Bellite* and *Securite.*

When gently heated, it volatilises without explosion or ignition, and burns slowly when unconfined. It is a brownish yellow powder, having an odour of nitro-benzole. It is necessary to use a powerful detonator to explode a charge. It is a safe explosive, flameless, and its products of decomposition are not capable of further oxidation,—a property very desirable when used in fiery or dusty mines.

The definition of the composition of Roburite, as licensed in this country, is as follows :—

(*a.*) Nitrate of ammonium, with or without an admixture of nitrate of sodium and neutral sulphate of ammonium, or either of them, provided that the amount of nitrate of sodium so added shall in no case exceed 50 per cent. of the total amount of nitrates present ; and

(*b.*) Thoroughly purified chlorinated di-nitro-benzole, with or without the addition of thoroughly purified chloro-nitro-naphthalene and chloro-nitro-benzole, provided that such chlorinated di-nitro-benzole shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of chlorinated di-nitro-benzole, and that the proportions of chloro-nitro-naphthalene and chloro-nitro-benzole shall not amount to more than 2 per cent. and 5 per cent. respectively of the finished explosive.

Roburite No. 2 consists of *Roburite* as above defined, with the addition of chloride of ammonium and sulphate of magnesium, or either of them.

Gathurst Powder is a modification of *Roburite*, the essential difference being that nitrate of potash or soda is substituted for nitrate of ammonia.

Schultze Gunpowder.

Soluble Nitro-Lignin	25.0 parts.
Insoluble Nitro-Lignin	23.5 ,,
Lignin (unconverted)	13.2 ,,
Nitrates of Potassium and Barium	32.5 ,,
Paraffin	3.8 ,,

OTHER VARIETIES OF SCHULTZE ARE—

	Sporting.	Rifle.	Blasting.
Nitro-Tar (or similar Nitro-Compound)	12	10	15
Pyroxiline	60 to 80	280 to 300	10
Barium Nitrate	60 to 80	100 to 120	—
Potassium Nitrate	8 to 10	40 to 50	75
Sulphur	—	10	10

Smokeless Powder.

This powder, as manufactured near Ware, is defined as follows :—

"Consisting of nitro-lignin carefully purified and mixed, or impregnated with a nitrate or nitrates (other than nitrate of lead), and with or without starch or collodion or turmeric, or similar vegetable colouring matter, provided that such collodion shall consist of carefully purified nitro-lignin dissolved in commercially pure ether and alcohol, and with or without such other substances as may from time to time be approved by a Secretary of State."

There have been numerous proposals made for manufacturing smokeless powders, which may be divided into two classes—(1) containing nitro-glycerine, and being some modification of blasting gelatine, such as *Ballistite;* (2) principally composed of nitro-cellulose treated with solvents and gelatinised, or otherwise rendered available for incorporating certain other ingredients.

Abel, in his patent (Spec. No. 14803, 14.9.86), proposed a mixture consisting of nitro-cotton and nitrate of ammonia, waterproofed by petroleum or camphoretted (cordite).

Nobel, in his patent (Spec. No. 1471, 31.1.88), proposed 100 parts of nitro-glycerine, 10 camphor, 200 benzole, and 50 soluble nitro-cellulose. The benzole is evaporated, and the doughy material mixed by passing through rollers heated by steam to 120° or 140° F. Another mixture is 100 of nitro-glycerine, 10 to 25 of camphor, 200 to 400 acetate of amyl, 200 soluble nitro-cellulose. Nitro-starch may be substituted for a part of the nitro-glycerine.

Engel (Spec. No. 6022, 25.4.87) dissolves nitro-cellulose in acetic ether, acetone, &c., and adds a nitrate or chlorate and a small quantity of naphthalene. This smokeless explosive is a heavy, horny body, having a vitreous fracture.

Anderson (Spec. No. 13308, 20.7.89) dissolves nitro-cotton in acetic ether diluted with 10 to 20 per cent. benzoline. The proportions are about 32 fluid ounces of the liquid to 1 lb. of dry nitro-cotton. The product is "squirted," and allowed to harden.

Maxim (Spec. No. 16213, 8.12.88) treats gun-cotton with acetone or acetone alcohol and ether in an exhausted vessel, so as to eliminate air bubbles, and consequently obtains a very hard material. In his patent (Spec. No. 4477, 14.4.89) he adds oil (preferably castor oil) to compounds of dissolved gun-cotton, nitro-glycerine, &c., to produce a slow burning explosive for small arms. Suitable proportions are 2 to 5 per cent. castor-oil, 10 to 16 per cent. nitro-glycerine, and the remainder gun-cotton.

Tonite or Cotton Powder.

This explosive is a nitrated gun-cotton, the nitrate generally used being barium nitrate. It is issued in cartridges coated with paraffin. *Tonite No.* 2 is the above with an addition of charcoal. *Tonite No.* 3 consists of a mixture of di-nitro-benzole, gun-cotton, nitrates of soda, barium, or potash and chalk. The three varieties are authorised explosives.

Composition of Notable Picric Powders—Division II.

Borlinetto's Powder.

Picric Acid - - -	10 parts.
Nitrate of Soda - -	10 ,,
Chromate of Potash -	8½ ,,

Bruyere's Powder.

Picrate of Ammonia -	54 parts.
Saltpetre - - -	46 ,,

Bronolith.

Two varieties of Bronolith have been approved for licensing, and are defined as follows :—

Bronolith No. 1, consisting of a mixture of saltpetre, dextrine, sugar, and charcoal, with or without the addition of picrates, barium, sodium, and potassium, or any of them, and with or without the addition of nitro-naphthalene. The amount of picrates in the finished explosive is not to exceed 5 per cent., or the nitro-naphthalene 8 per cent.

Bronolith No. 2 is composed of the same ingredients as No. 1, but there is no limitation as to the amount of picrates. The total amount of saltpetre and nitro-naphthalene is not to exceed 10 per cent.

Designolle's Powders.

	For Torpedoes and Shells.		For Guns.			For Small Arms.	
			Ordinary.		Heavy.		
Picrate of Potash - - -	55	50	16.4	9.6	9	28.6	22.9
Saltpetre - - - -	45	50	74.4	79.7	80	65.0	69.4
Charcoal - - - -	—		9.2	10.7	11	6.4	7.7

Melinite.

Picric acid embedded in collodion. Also fused picric acid used with a gun-cotton primer.

Picric Powder.

(Abel's.)

Saltpetre - - -	3 parts.
Picrate of Ammonia -	2 ,,

Turpin's Explosives.

Same as Melinite.

Emmensite.

This explosive is produced by treating picric acid with fuming nitric acid. The crystals thus produced are mixed with a nitrate.

Victorite.

Chlorate of Potash -	80 parts.
Picric Acid - - -	110 ,,
Nitrate of Potash, Soda, or Baryta - - -	10 ,,
Charcoal - - -	5 ,,

Tschirner's Powder.

Picric Acid - - -	57 parts.
Chlorate of Potash -	43 ,,
Resin - - - -	5 ,,

This mixture is moistened with benzene or petroleum to dissolve the resin.

DETERMINATION OF STABILITY OF EXPLOSIVES.

Instructions as to Tests issued by the Home Office.

Heat Test as applied to Explosives of the Nitro-Compound Class (as defined by Order in Council No. 1, of 5th August 1875).

General Instructions.

Apparatus required.

1. A water bath, consisting of a spherical glass or copper vessel (*a*), Fig. 6, of about 8 inches diameter, and with an aperture of about 5 inches; the bath is filled with water to within $\frac{1}{4}$ inch of the edge. It has a loose cover of sheet copper about 6 inches in diameter (*b*), and rests on a tripod stand about 14 inches high (*c*), which is covered with coarse iron wire gauze (*e*), and is surrounded with a screen of thin sheet tin or copper (*d*). Within the latter is placed an argand burner (*f*) with glass chimney. The cover *b* has

four holes arranged as seen in Fig. 7, No. 4 to receive the regulator, No. 3 the thermometer, Nos. 1 and 2 the test tubes containing the gun-cotton or other materials to be tested. Around holes 1 and 2 on the other side of the cover are soldered three pieces of brass wire with points slightly converging (Fig. 8); these act as springs and allow the test-tubes to be easily placed in position and removed.

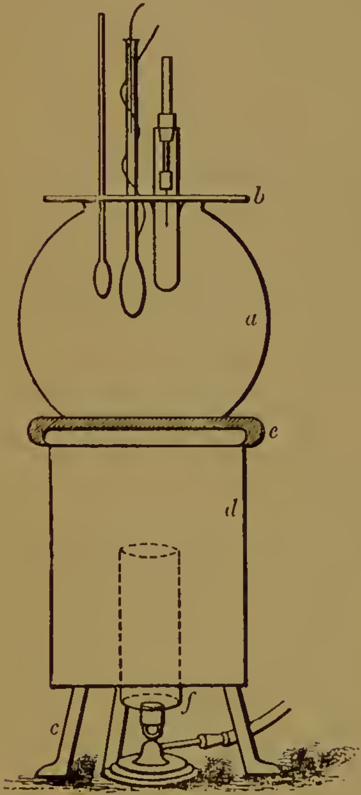

FIG. 6.

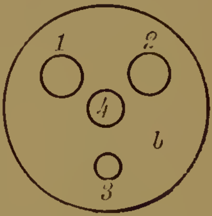

FIG. 7.

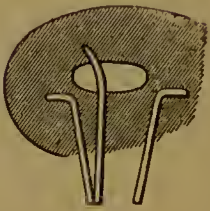

FIG. 8.

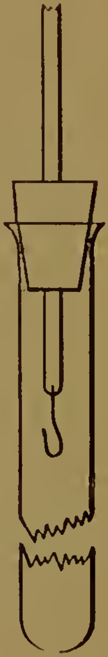

FIG. 9.

*2. Scheibler's or Page's temperature regulator.

*3. Two cells of Le Clanché's battery No. 1 } if Scheibler's regulator is used.
*4. A few yards of insulated copper wire }

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* This is not absolutely required, as the temperature of the bath can be kept constant by proper attention to the heating flame.

5. Test tubes from $5\frac{1}{4}$ to $5\frac{1}{2}$ inches long, and of such diameter that they will hold from 20 to 22 cubic centimetres of water when filled to a height of 5 inches.

6. Indiarubber stoppers, fitting the test tubes and carrying an arrangement for holding the test paper, viz., a narrow glass tube passing through the centre of the stopper, drawn out so as to form a hook, or terminating in a platinum wire hook (Fig. 9).

7. A thermometer, with range not less than from 30° to 212° Fahrenheit.

8. A minute clock.

Materials Required.

a. Test Paper.—The test paper is prepared as follows:—45 grains of white maize starch (corn-flour), previously washed with cold water, are added to $8\frac{1}{2}$ ounces of distilled water; the mixture is stirred, heated to boiling, and kept gently boiling for ten minutes; 15 grains of pure potassium iodide (*i.e.*, which has been re-crystallised from alcohol) are dissolved in $8\frac{1}{2}$ ounces of distilled water. The two solutions are thoroughly mixed and allowed to get cold. Strips or sheets of white English filter paper, previously washed with water and re-dried, are dipped into the solution thus prepared, and allowed to remain in it for not less than ten seconds; they are then allowed to drain and dry in a place free from laboratory fumes and dust. The upper and lower margins of the strips or sheets are cut off, and the paper is preserved in well-stoppered or corked bottles *and in the dark.* When the paper is freshly prepared, and as long as it remains in good condition, a drop of dilute acetic acid, put on the paper with a glass rod, produces no coloration. In process of time, however, the stronger the light to which the paper is exposed, the sooner a drop of the acid produces a brown or bluish coloration (a single hour of direct sunlight produces a marked effect), and whenever this is the case the paper should be rejected. On this account it is advisable not to prepare too much of the test paper at one time, but to prepare it fresh every month or so.

b. Standard Tint Paper.—A solution of caramel in water is made of such concentration that when diluted one hundred times (10 c.c. made up to 1 litre) the tint of this diluted solution equals the tint produced by the Nessler test in 100 c.c. water containing 0.000075 grm. of ammonia or 0.00023505 grm. of chloride of ammonium. With this caramel solution lines are drawn on strips of white filter paper (which paper must be carefully washed with distilled water in the first instance, to remove any traces of bleaching matter, and dried) by means of a clean quill pen. When the marks thus produced are dry, the paper is cut into pieces of the same size as the test paper previously described, in such a way that each piece has a brown line across it near the middle of its length, and only such strips are preserved in which the brown line has a breadth varying from $\frac{1}{2}$ mm. to 1 mm. ($\frac{1}{50}$ inch to $\frac{1}{25}$ inch).

Testing Dynamite, Blasting Gelatine, and other Explosives of the First Division of the Nitro-compound Class.

(A.) Dynamite, &c. &c.

Nitro-glycerine preparations, from which the nitro-glycerine can be extracted in the manner described below, *must* satisfy the following test, otherwise they will not be considered as manufactured with "thoroughly purified nitro-glycerine" within the terms of the license.

This test, however, though at present looked upon as the most important, as far as testing the purity of the nitro-glycerine is concerned, is only one of several which any given sample of nitro-glycerine preparation has to satisfy in order to establish its compliance with the definition in the license.

The test, although at present accepted as regulating and defining the meaning of the terms "thoroughly purified," may nevertheless be modified or superseded if, in the opinion of the Home Office, such alteration may at any time be deemed necessary.

Apparatus Required.—A funnel 2 inches across (*d*), a cylindrical measure divided into grains (*e*). (*See* Fig. 10.)

Mode of Operation.—About 300 to 400 grains of dynamite (*b*) finely divided are placed into the funnel, which has previously been loosely plugged by some freshly ignited asbestos (*a*).

The surface is smoothed by means of a flat-headed glass rod or stopper, and some clean washed and dried kieselguhr (*c*) is spread over it to the depth of about $\frac{1}{8}$ inch.

Water is next carefully dropped from a wash bottle upon this kieselguhr, and when the first portion has been soaked up, more is added; this is repeated until sufficient nitro-glycerine has been collected in the graduated measure (*e*) below.

If any water should have passed through with the nitro-glycerine, it should be removed with a piece of blotting paper, and the nitro-glycerine, if necessary, filtered through a dry paper filter.

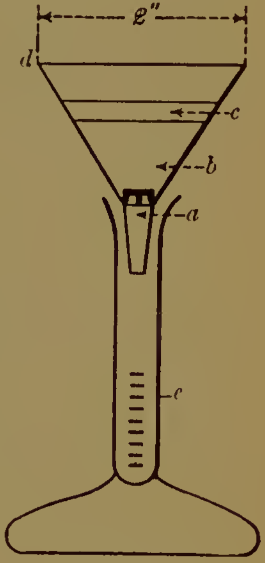

FIG. 10.

Application of the Test.—The thermometer is fixed so as to be inserted through the lid of the water bath described before into the water (which is to be steadily maintained at a temperature of 160° F.) to a depth of $2\frac{3}{4}$ inches. Fifty grains of nitro-glycerine, to be tested, are weighed out into a test tube in such a way as not to soil the sides of the tube. A test paper is fixed on the hook of the glass rod so that when inserted into the tube it will be in a vertical position. A sufficient amount of a mixture of half distilled water and half glycerine to moisten the upper half of the paper is now applied to the upper edge of the test paper, by means of a camel's-hair pencil, the cork carrying the rod and paper is fixed into the test tube and the position of the paper adjusted so that its lower edge is about half-way down the tube; the latter is then inserted through one of the perforations of the cover, to such a depth that the lower margin of the moistened part of the paper is about ⅝ of an inch above the surface of the cover. The test is complete when the faint brown line, which after a time makes its appearance at the line of boundary between the dry and moist part of the paper, equals in tint the brown line of the standard tint paper.

The nitro-glycerine under examination will not be considered as *thoroughly purified* within the terms of the license unless the time necessary to produce the standard tint as above described IS AT LEAST 15 MINUTES.

(B.) Blasting Gelatine, Gelatine Dynamite, and Analogous Preparations.

Fifty grains of blasting gelatine are to be intimately incorporated with 100 grains of French chalk. This may be readily effected by carefully working the two materials together with a wooden pestle in a wooden mortar. The mixture is to be gradually introduced into a test tube of the dimensions recommended above for the dynamite heat test, with the aid of gentle tapping upon the table, between the introduction of successive portions of the mixture into the tube, so that when the tube contains all the mixture it shall be filled to the extent of 1¾ inch of its height. The test paper is then to be inserted, and the heat is to be applied in the manner prescribed above for the dynamite heat test, and the sample tested as to withstand exposure to 160° F. for a period of ten minutes, before producing a discoloration of the test papers corresponding in tint to the standard colour test which is employed for governing the results of the dynamite heat test.

Testing Gun-Cotton, Schultze Gunpowder, E. C. Powder, and other Explosives of the Second Division of the Nitro-Compound Class.

(A.) Compressed Gun-Cotton, Tonite, &c. &c.

Sufficient material to serve for two or more tests is removed from the centre of the cartridge by gentle scraping, and, if necessary, further reduced by rubbing between the fingers.

The fine powder thus produced is spread out in a thin layer upon a paper tray 6 inches by $4\frac{1}{2}$ inches, which is then placed inside a water oven, kept as nearly as possible at 120° F.

The wire gauze shelves in the oven should be about 3 inches apart. The sample is allowed to remain at rest for fifteen minutes in the oven, the door of which is left wide open.

After the lapse of fifteen minutes the tray is removed and exposed to the air of the room for two hours, the sample being at some point within that time rubbed upon the tray with the hand, in order to reduce it to a fine and uniform state of division.

Application of the Test.—The cover of the water bath is fitted with the gas regulator which is inserted through the centre hole (No. 4). The thermometer is fixed into hole No. 3. The water in the bath is then heated to 150° F., and the regulator set to maintain that temperature.

Twenty grains of the sample to be tested are weighed out, placed in the test tube, and gently pressed down until the specimen occupies a space of as nearly as possible $1\frac{5}{16}$ inch in a test tube of the dimensions specified.

A test paper is affixed to the hook of the glass rod or tube, and moistened by touching the upper edge with a drop of distilled water containing 50 per cent. of Price's glycerine. The quantity of liquid used must be only sufficient to moisten about half of the paper.

The cork carrying the rod and test paper is then fixed into the test tube, and the latter inserted into the bath to a depth of $2\frac{1}{2}$ inches, measured from the cover, the regulator and thermometer being inserted to the same depth. The test paper is to be kept near the top of the test tube, but clear of the cork, until the tube has been immersed for about five minutes.

A ring of moisture will about this time be deposited upon the sides of the test tube a little above the cover of the bath; the glass rod must then be lowered until the lower margin of the moistened part of the paper is on a level with the bottom of the ring of moisture in the tube. The paper is now closely watched.

The test is complete when a very faint brown coloration makes its appearance at the line of boundary between the dry and moist parts of the paper.

The interval of time between the first insertion of the tube containing the sample of gun-cotton in the water at 150° and the first appearance of discoloration on the paper constitutes the test, and this interval of time must be *not less* than ten minutes, or the sample will not be accepted as properly purified.

(B.) Schultze Powder, E. C. Powder, Collodion-Cotton, &c. &c.

Sufficient of the sample, without further mechanical division, is dried in the oven as above, and then exposed for two hours to the air. The test as directed above for compressed gun-cotton, &c., is then applied, the minimum duration of test being the same, viz., ten minutes.

Exudation and Liquefaction Test for Blasting Gelatine, Gelatine Dynamite, and Analogous Preparations.

Test for Liquefaction.—A cylinder of blasting gelatine is to be cut from the cartridge to be tested, the length of the cylinder to be about equal to its diameter, and the ends being cut flat.

The cylinder is to be placed on end on a flat surface without any wrapper, and secured by a pin passing vertically through its centre.

In this condition the cylinder is to be exposed for 144 consecutive hours (six days and nights) to a temperature ranging from 85° to 90° Fahrenheit (inclusive), and during such exposure the cylinder shall not diminish in height by more than one-fourth of its original height, and the upper cut surface shall retain its flatness and the sharpness of its edge.

Note.—If the blasting gelatine and the gelatine dynamite to be tested be not made up in a cylindrical form, the above test is to be applied with the necessary modifications.

Test for Liability of Exudation.—There shall be no separation from the general mass of the blasting gelatine or gelatine dynamite of a substance of less consistency than the bulk of the remaining portion of the material, under any conditions of storage, transport, or use, or when the material is subjected three times in succession to alternate freezing and thawing, or when subjected to the liquefaction test hereinbefore described.

IV.—CHLORATE-MIXTURE CLASS.

The term "chlorate-mixture" means any explosive containing a chlorate.

The chlorate-mixture class has two divisions.

Division 1 comprises such explosives as—

Horsley's blasting powder,
Brain's blasting powder,

and any chlorate preparation which consists partly of nitro-glycerine or of some other liquid nitro-compound.

Division 2 comprises such explosives as—

Horsley's original blasting powder,
Ehrhardt's powder,
Reveley's powder,
Hochstadter's blasting charges,
Reichen's blasting charges,
Teutonite,
Chlorated gun-cotton,

and any chlorate-mixture as before defined, which is not comprised in the first division.

Owing to the uncertainty of reliance upon the chlorate class of explosives, they have not received any commercial application in this country. They have, however, been used with some degree of success by military experts.

The following is a list of names of the explosives proposed, containing chlorate of potash, &c. :—

Asphaline.
Augendre's Powder (also known as White German or American Powder).
Baron and Cauvet's Powders.
Bellford's Powder.
Bolton's Powder.
Cotter's Powder.
Cornet Powder.
Davey's Powder.
Davies' Powder.
Diripsite.
Dynamogen.
Ehrhardt's Powders.
Etnite.
Explosive Paper.
Fenton's Powder.
French Green Powder.
Fuch's Powder.
Goetz' Powder.
Gomez' Powders.
Graham's Powder.
Hafenegger's Powders.
Hahn's Powder.
Hall's Powder.
Hannan's Powder.
Harrison's Powder.
Hart's Powder.
Himley's Powder.
Hochstätter's Compound.
Horsley's Powder.
Jaline.
Kellow's Powders.
Knaffl's Powder.
Köhler's Powder.
Macintosh's Powder.
Melland's Paper Powder.
Melville's Powders.
Michalowski's Miner's Powder.
Monnier's Powder.
Nisser's Powders.
Noble's Powders.
Paron's Explosive.
Pattison's Explosive.
Peley's Explosive Paper.
Pellier's Powder,
Pertuisets' Powder.
Pohl's Powder.
Pyronome.
Rack-a-Rock.
Raves' Powder.
Reichen's Paper.
Reveley's Powder.
Reynolds' Powder.
Rickers' Powder.
Roberts' Powder.
Roger's Explosive.
Safety Gunpowder.
Schlesinger's Powder.
Saulaville & Laligant's Explosives.
Sharp's Powder.
Siemens' Powder.
Silesite.
Sleeper's Powder.
Turpin's Powder.
Vril's Explosive.
Wigfall's Powder.
Williams' Powder.
Zaliwsky's Powder.

The following list shows the compositions of the more notable explosives of the chlorate-mixture class :—

Asphaline.

This explosive consists of wheat or barley bran impregnated with chlorate of potash (in a proportion not exceeding 54 parts of chlorate to 42 parts of bran) mixed with saltpetre and sulphate of potash (in a proportion not exceeding 4 parts to 42 parts of bran). Paraffin oil, paraffin ozokerit, and soap, or some of them, may be added. The compound is coloured pink with fuchsine.

Augendre's Powder.

Chlorate of Potash	50 parts.
Yellow Prussiate of Potash	25 ,,
Cane Sugar	25 ,,

Davey's Powders.

	No. 1.	No. 2.
Chlorate of Potash	6 pts.	6 pts.
Nitrate of Potash	5 ,,	3 ,,
Yellow Prussiate of Potash	2 ,,	4 ,,
Bichromate of Potash	2 ,,	–
Sulphide of Antimony	5 ,,	3 ,,

Baron and Cauvet's Explosives.

	No. 1.	No. 2.
Chlorate of Potash	50 pts.	50 pts.
Prussiate of Potash	50 ,,	25 ,,
Sugar	—	25 ,,

Davies' Powder.

Yellow Prussiate of Potash	4 parts.
Chloride of Potassium	8 ,,
Loaf Sugar	2 ,,
Crystallised Sugar	2 ,,
Sulphur	1 ,,

Dynamogen.

Yellow Prussiate of Potash	17 parts.
Water	150 ,,
Charcoal	17 ,,

These are boiled, well stirred, and then allowed to cool, after which is added—

Potash	35 parts.
Chlorate of Potash	70 ,,
Starch	10 ,,
Water	50 ,,

The whole is made into a thin paste and brushed on to a filtering paper, three coats being laid on each side. The paper thus charged is dried, cut up, and then rolled into cartridges.

Ehrhardt's Powders.

	For Artillery.	For Blasting.	For Shells.
Chlorate of Potash	1	1	1
Saltpetre	1	1	–
Charcoal	–	4	–
Tannic Acid	1	2	1

French Green Powder.

Chlorate of Potash	14	parts.
Picric Acid	4	,,
Yellow Prussiate of Potash	3	,,

Hahn's Powder.

Chlorate of Potash	367.5	parts.
Tersulphide of Antimony	168.3	,,
Spermaceti	46.0	,,
Charcoal	18.0	,,

Jaline.

Nitrate of Potash	65 to 75	parts.
Sulphur	10	,,
Lignite	10 to 50	,,
Picrate of Soda	3 to 8	,,
Chlorate of Potash	2	,,

Knaffl's Powder.

Chlorate of Potash	46	parts.
Nitrate of Potash	26	,,
Sulphur	15	,,
Almate of Ammonia	10	,,

Monnier's Powder.

Chlorate of Potash	71	parts.
Sugar	16	,,
Charcoal	6	,,
Coal Tar	7	,,

Pyronome.

Saltpetre	69	parts.
Sulphur	9	,,
Charcoal	10	,,
Metallic Antimony	8	,,
Chlorate of Potash	5	,,
Rye Flour	4	,,

Goetz's Powder.

Chlorate of Potash	10	parts.
Solution of Glucose	10	,,
Charcoal in Powder	3	,,
Sulphur	2	,,
Amorphous Phosphorus	1	,,
Picrate of Lead	3	,,

Horsley's Powder.

Chlorate of Potash	3	parts.
Gall Nuts	1	,,

Kellow's Powder.

Nitrate of Soda	30	or	36	parts.
Nitrate of Potash	8	,,	4	,,
Chlorate of Potash	12	,,	6	,,
Sulphur	10	,,	10	,,
Tan and Sawdust	46	,,	50	,,

Kohler's Powder.

Chlorate of Potash	70	parts.
Sulphur	20	,,
Charcoal	10	,,

Nisser's Powder.

Yellow Prussiate of Potash	1.5	parts.
Bichromate	2.0	,,
Perchlorate, or Chlorate of Potash	10.5	,,
Nitrates of Soda and Potash	44.5	,,
Vegetable Matter	6.5	,,
Mineral and Vegetable Carbon	19.5	,,
Sulphur	15.5	,,

Reveley's Powder.

Chlorate of Potash	40	parts.
Yellow Prussiate of Potash	29	,,
Loaf Sugar	23	,,

Rack-a-Rock.

This explosive consists of compressed chlorate of potash, in the shape of cartridges, and when required for use are dipped into such liquids as "dead oil" (from coal tar), or a mixture of equal parts of this oil and bisulphide of carbon with or without the addition of 3 per cent. of sulphur.

Roger's Explosive.

Chlorate of Potash - -	5 parts.
Cascarilla Bark - -	2 ,,
Corundum - - -	3 ,,
Indiarubber Solution -	3 ,,

Sharp's Powder.

Saltpetre - - -	2 parts.
Chlorate of Potash - -	2 ,,
Yellow Prussiate of Potash	1 ,,
Potash - - - -	1 ,,
Sulphur - - -	2 ,,

Schlesinger's Powder.

Chlorate of Potash - -	3 parts.
Sulphide of Antimony -	3 ,,
Flowers of Sulphur -	1 ,,

Vril.

	1.	2.
Chlorate of Potash -	50.0	48.0
Yellow Prussiate of Potash	4.5	9.1
Nitrate of Potash - -	25.0	24.3
Willow Charcoal - -	12.5	11.6
Paraffin - - -	6.0	6.5
Ferric Oxide - -	2.0	0.5

V.—FULMINATE CLASS.

The term "fulminate" means any chemical compound or mechanical mixture, whether included in the foregoing classes or not, which, from its great susceptibility to detonation, is suitable for employment in percussion caps or any other appliances for developing detonation, or which, from its extreme sensibility to explosion and from its great instability (that is to say, readiness to undergo decomposition from very slight exciting causes) is especially dangerous.

This class consists of two divisions.

Division 1 comprises such compounds as the fulminates of silver and of mercury and preparations of these substances, such as are used in percussion caps; any preparation consisting of a mixture of a chlorate with phosphorus, or certain descriptions of phosphorus compounds, with or without the addition of carbonaceous matter; and any preparation consisting of a mixture of a chlorate with sulphur, or with a sulphuret, with or without carbonaceous matter.

Division 2 comprises such substances as the chloride and the iodide of nitrogen, fulminating gold and silver, diazobenzol, and the nitrate of diazobenzol.

The following are particulars of some of the members of this class :—

Fulminates, &c.

A fulminate is a salt of an acid termed fulminic acid. This acid, however, has not been isolated. The metallic salts are generally highly explosive with heat or slight friction. Fulminate of silver is liable to spontaneous explosion. They are used in percussion caps, amorces or toy caps, and detonators.

Aniline Fulminante (*Diazobenzol*).—This compound is prepared by acting upon nitrate of aniline with nitrous acid, and crystallises in long colourless needles. It decomposes on exposure, and turns pink, and is very unstable, decomposing with very little friction. It violently explodes when heated to 200° F.

Fulminate of Mercury.—This is the fulminate which is generally used for percussion caps and detonators. It is prepared by dissolving mercury in nitric acid, and then adding alcohol to the metallic solution. It generally has a greyish colour, and explodes violently with slight friction or percussion. When heated to 360° F., it decomposes with violent explosion. When soaked with water it is not explosive.

Fulminate of Silver.—This substance is prepared by dissolving silver in nitric acid, and adding alcohol, when it is obtained as small white needles. This is a more sensitive fulminate than that of mercury. It is liable to spontaneous explosion, and can be decomposed under water by friction. It is used in small quantities for bon-bon crackers and such-like toy fireworks.

Fulminating Gold.—This is a very explosive brown powder, produced by adding ammonia to perchloride of gold.

Fulminating Platinum is a black powder formed when ammonia is added to a solution of binoxide of platinum in sulphuric acid. It is a most violent explosive.

Chloride of Nitrogen.—This substance is produced by acting upon chloride of ammonium solution with chlorine gas. It is an oily liquid having a specific gravity of 1.64. It is one of the most dangerous explosives known. It explodes with great violence when heated to 210° F. It also violently detonates with the slightest friction, or when in contact with inflammable bodies, such as phosphorus, turpentine, oils, &c. It has no commercial applications.

Iodide of Nitrogen.—This is a black powder prepared by digesting iodine in a cold solution of ammonia. It is highly explosive, mere friction with a feather is sufficient for its detonation, and it often explodes without any apparent cause.

VI.—AMMUNITION CLASS.

The term "ammunition" means an explosive of any of the foregoing classes when enclosed in any case or contrivance, or otherwise adapted or prepared so as to form a cartridge or charge for small arms, cannon, or any other weapon, or for blasting, or to form any safety or other fuse for blasting or for shells, or to form any tube for firing explosives, or to form a percussion cap, a detonator, a fog signal, a shell, a torpedo, a war rocket, or other contrivance other than a firework.

The term "percussion cap" does not include a detonator.

The term "detonator" means a capsule or case is of such strength and construction, and contains an explosive of the fulminate explosive class in such quantity, that the explosion of one capsule or case will communicate the explosion to other like capsules or cases.

The term "safety fuse" means a fuse for blasting which burns and does not explode, and which does not contain its own means of ignition, and which is of such strength and construction, and contains an explosive in such quantity that the burning of such fuse will not communicate laterally with other like fuses.

The ammunition class has three divisions :—

Division 1 comprises conclusively—

Safety cartridges.
Safety fuses for blasting.
Railway fog signals.
Percussion caps.

Division 2 comprises any ammunition, as before defined, which does not contain its own means of ignition, and is not included in Division 1, such as—

Cartridges for small arms which are not safety cartridges.

Cartridges and charges for cannon, shells, mines, blasting, or other like purposes.

Shells and torpedoes containing any explosives.
Fuses for blasting, which are not safety fuses.
Fuses for shells.
Tubes for firing explosives.
War rockets.

Which do not contain their own means of ignition.

Division 3 comprises any ammunition, as before defined, which contains its own means of ignition, and is not included in Division 1, such as—

Detonators.
Cartridges for small arms, which are not safety cartridges.
Fuses for blasting, which are not safety fuses.
Fuses for shells.
Tubes for firing explosives.

Which do not contain their own means of ignition.

By "ammunition containing its own means of ignition" is meant ammunition having an arrangement, whether attached to it or forming part of it, which is adapted to explode or fire the same by friction or percussion.

Division 1.

Percussion Caps. *O. in C., No.* 1.

Railway Fog Signals, of such strength and construction, and containing an explosive in such quantity that the explosion of one such railway fog signal will not communicate the explosion to other like railway fog signals.

Safety Cartridges, consisting of cartridges for small arms, of which the case can be extracted from the small arm after firing, and which are so closed as to prevent any explosion in one cartridge being communicated to other cartridges (s. 108).

Safety Fuse, consisting of a fuse for blasting, which burns and does not explode, and which does not contain its own means of ignition, and which is of such strength and construction, and contains an explosive in such quantity that the burning of such fuze will not communicate laterally with other like fuses. *O. in C., No.* 1.

Safety Firing Tubes, No. 1, consisting of a tube of metal or other suitable material, containing a percussion cap and suitable mechanical appliances for firing the same.

Tube Safety Fuse, consisting of a pipe or tube of pewter, coated externally with tarred yarns, tapes, or other suitable covering, and containing gunpowder in the proportion of not more than one and a half ($1\frac{1}{2}$) ounces to every twenty-four (24) feet of fuse.

Division 2.

(*Not containing its own means of ignition.*)

Cartridges for Small Arms (which are not Safety Cartridges). *O. in C., No.* 1.

Cartridges for Cannon, Shells, Mines, Blasting, or other like purposes. *O. in C., No.* 1 ; *also Section*, 44.

Abel's Electric Fuses, consisting of a case of wood or other suitable material, containing two insulated wires, the terminals of which are (*a*) embedded in a charge not exceeding 2 grains of the priming composition No. 1, hereinafter specified, or (*b*) connected by a bridge of fine wire composed of a platinum alloy, steel, or other suitable material, the said bridge being embedded in a charge, not exceeding 10 grains of the priming material No. 2, hereinafter specified; the case being either (*a*) filled with a charge not exceeding 20 grains of gunpowder, and closed at the end; or (*b*) empty, and open at the end ; or (*c*) fitted with a small hollow cylinder of copper, sheet tin, or other material suitable for conversion into a detonator.

Priming composition No. 1, consisting of sulphide of copper, phosphide of copper, and chlorate of potash, intimately mixed together.

Priming composition No. 2, consisting of gunpowder and thoroughly purified gun-cotton.

Brain's Electric Fuses, consisting of a case of wood or other suitable material, containing two insulated copper wires, the terminals of which are embedded in a priming composition consisting of an intimate mixture of chlorate of potash, native sulphide of antimony, and sub-phosphide of copper.

Electric Fuses (Smith's Patent), consisting of a plug of sulphur containing two copper wires connected by a bridge of fine platinum or other suitable wire surrounded by a priming charge of fulminate of mercury not exceeding one-fifth of a grain in any one fuse.

High Tension Electric Fuses, consisting of a case of wood or other suitable material, containing two insulated wires, the terminals of which are embedded in a charge not exceeding two grains of a priming composition, consisting of sulphide of copper, phosphide of copper, and chlorate of potash intimately mixed together, the case being filled with a charge not exceeding 20 grains of gunpowder or carefully purified collodion cotton, and closed at the end.

High Tension Electric Fuses, consisting of a plug of wood or other suitable material, containing two insulated copper wires, the terminals of which are embedded in a priming composition, consisting of an intimate mixture of chlorate of potassium, sulphide of antimony, silver precipitate, and plumbago.

High Tension Electric Fuses (Brain's Patent), consisting of a case of wood or other suitable material, containing two insulated copper wires, the terminals of which are embedded in a priming composition consisting of an intimate mixture of chlorate of potash, native sulphide of antimony, platinum, and silver.

Low Tension Electric Fuses, consisting of a case of glass or other suitable material, containing two insulated wires, the terminals of which are connected by a bridge of fine wire composed of a platinum alloy.

Low Tension Electric Fuses, consisting of a case of glass or other suitable material, containing two insulated wires, the terminals of which are connected by a bridge of fine wire composed of a platinum alloy, the case being filled with a charge not exceeding twenty (20) grains of (*a*) gunpowder, or (*b*) carefully purified collodion cotton, or (*c*) carefully purified gun-cotton.

Low Tension Electric Fuses, consisting of a case of glass or other suitable material, containing two insulated wires, the terminals of which are connected by a bridge of platinum wire, or other suitable material, embedded in a charge not exceeding 20 grains of (*a*) gunpowder, or (*b*) carefully purified collodion cotton, or (*c*) carefully purified gun-cotton, or (*d*) chlorate of potash and sulphide of antimony.

Spon's Electric Fuses, consisting of a case of metal, wood, paper, or other suitable material, containing two or more insulated wires, the terminals of which are (*a*) embedded in a charge not exceeding 5 grains of one or the other of the priming compositions (1), (2), (3), hereinafter specified; or (*b*) connected by a bridge of fine wire composed of a platinum alloy, steel, or other suitable material, the said bridge being embedded in a charge not exceeding 10 grains of one or other of the priming compositions (4), (5), hereinafter mentioned.

Priming composition (1).—Chlorate of potash and sulphide of antimony, with or without powdered carbon.

Priming composition (2).—Chlorate of potash, sulphide of antimony, and phosphide of copper.

Priming composition (3).—Chlorate of potash, sulphide of copper, and phosphide of copper.

Priming composition (4).—Gun-cotton thoroughly purified.

Priming composition (5).—Gun-cotton thoroughly purified, chlorate of potash, and powdered galls.

Electric Primers, consisting of a case of metal or other suitable material, containing two or more insulated wires, the terminals of which are connected by a thin bridge of platinum wire or other suitable material embedded in a charge not exceeding 15 grains of a priming composition consisting of gunpowder and thoroughly purified gun-cotton.

Abel's Electric Tubes, consisting of a case of wood or other suitable material, containing two insulated wires, the terminals of which are (*a*) embedded in a charge not exceeding 2 grains of the priming composition No. 1, consisting of sulphide of copper, phosphide of copper, and chlorate of potash, intimately mixed together, or (*b*) connected by a bridge of fine wire composed of platinum alloy, steel, or other suitable material, the said bridge being embedded in a charge not exceeding 10 grains of the priming composition No. 2, viz., consisting of gunpowder and thoroughly purified gun-cotton, the case being fitted to a small cylindrical tube of quill, metal, or paper, or other suitable material, charged with gunpowder, and having a hollow up the centre of the same.

Elswick Electric Tubes, consisting of a case of metal, wood, paper, or other suitable material, containing (*a*) two or more insulated wires, the terminals of which are connected by a fine wire of platinum or other suitable material embedded in a charge not exceeding 10 grains of gun-cotton thoroughly purified, and (*b*) a charge not exceeding 1 ounce of gunpowder; the said case being completely closed by means of a cork disc or other suitable material.

Fuses for Shells, consisting of cases of wood, metal, or other suitable material, charged or primed with fuse or other suitable composition, not containing their own means of ignition, and of such strength and construction that the explosion of one fuse will not communicate the explosion to other like fuses.

Fuses for Shells, consisting of cases of wood, metal, or other suitable material, charged or primed with fuse or other suitable composition, and whether or not containing their own means of ignition, and of such strength and construction that the explosion of one fuze will not produce an explosion *en masse* of other like fuses.

Gunpowder Fuses, consisting of cases of metal, wood, or other suitable material, containing a charge of gunpowder not exceeding 2 drams in each fuse.

Gun-Cotton Fuses, consisting of cases of metal, wood, or other suitable material, containing a charge of thoroughly purified gun-cotton not exceeding 2 drams in each fuse.

Instantaneous Fuse, consisting of a preparation of gunpowder, yarn, and a protective coating, which is not a safety fuse, and does not contain its own means of ignition.

Pain's Instantaneous Pyrotechnic Fuses, consisting of a closed case of paper, wood, or other suitable material, having affixed therein by means of a plug of sulphur two insulated copper wires, the terminals of which are connected by a bridge of fine wire consisting of platinum, platinum alloy, steel, or other suitable material, such bridge being embedded in a charge of gunpowder not exceeding 20 grains.

German Spills, consisting of cylindrical cases of paper, containing a charge of gunpowder not exceeding one pound (1 lb.) per gross, and primed at one end with touch paper, and at the other with mealed gunpowder, or primed at both ends with mealed gunpowder.

Miners' Squibs, consisting of a tube of paper or other suitable material partly filled with gunpowder in the proportion of not more than one pound (1 lb.) of gunpowder to every 500 squibs, and having one end closed with a plug of wax or other suitable material, and the other end closed by being twisted, and such twisted end being coated with sulphur, or not so coated.

Bickford's Patent Volley Firers, consisting of a small cylinder of tin-plate, zinc, wood, cardboard, or other suitable material, into one end of which is placed a socket or block of wood, or other suitable material, with a hole through the centre, and with a disc, wad, or cap made of, containing, or saturated with a priming paste of mealed powder at the base of the same; the said cylinder and socket or block being fitted with safety fuse or instantaneous fuse, or not so fitted.

Tubes for firing Explosives, consisting of cases of quill, metal, or paper, charged with mealed powder or other suitable explosive, and not containing their own means of ignition.

War Rockets, consisting of cases of iron or other suitable material, containing rocket composition, consisting of an intimate mixture of saltpetre, sulphur, and charcoal, and not containing their own means of ignition.

Division 3.

(*Containing its own means of ignition.*)

Cartridges for Small Arms (which are not Safety Cartridges). *O. in C.*, *No.* 1.

Electric Detonators, consisting of a detonator having two insulated wires connected by a fine platinum wire embedded in a priming composition consisting of chlorate of potash and sulphide of antimony, or purified gun cotton, and so placed and secured that no part of the wires can come into contact with the fulminate in such detonator.

Abel's Electric Detonator Fuses, consisting of a case of wood or other suitable material, containing two insulated wires, the terminals of which are (*a*) embedded in a charge not exceeding 2 grains of priming composition No. 1, hereinafter specified, or (*b*) connected by a bridge of fine wire composed of a platinum alloy, steel, or other suitable material, the said bridge being embedded in a charge not exceeding 10 grains of the priming material No. 2, hereinafter specified, the case being fitted with a detonator.

Priming composition No. 1, consisting of sulphide of copper, phosphide of copper, and chlorate of potash intimately mixed together.

Priming composition No. 2, consisting of gunpowder and thoroughly purified gun-cotton.

Bornhardt's Electric Detonator Fuses, consisting of a detonator as defined by Order in Council made under 106th section of the Act, such detonator having inserted therein two insulated wires, the terminals of which are embedded in a priming composition composed of chlorate of potash and native sulphide of antimony, and the detonator being so constructed, and the wires so adjusted and secured, that the terminals of the said wires cannot come into contact with the fulminate in the said detonators.

Brain's Electric Detonator Fuses, consisting of Brain's Electric Fuses as above described (*see* above in Division 2), and having attached thereto a detonator as defined by Order in Council made under the 106th section of the Explosives Act, 1875.

Electric Detonator Fuses (Smith's Patent), consisting of electric fuses as above described (*see* above in Division 2), and having attached thereto a detonator as defined by an Order in Council made under the 106th section of the said Act. Provided that no one such electric detonator fuse shall contain more than thirty (30) grains of explosive of the 5th (Fulminate) Class, as defined in the said Order.

High Tension Electric Detonator Fuses, consisting of high tension electric fuses as above described, and having attached thereto a detonator as defined by an Order in Council made under the 106th section of the Explosives Act, 1875.

High Tension Electric Detonator Fuses (Brain's Patent), consisting of high tension electric fuses as above described, and having attached thereto a detonator as defined by an Order in Council made under the 106th section of the Explosives Act, 1875.

High Tension Electric Detonator Fuses, consisting of high tension electric fuses (*see* above in Division 2), and having attached thereto a detonator.

Low Tension Electric Detonator Fuses, consisting of low tension electric fuses as above described, and having attached thereto a detonator as defined by an Order in Council made under the 106th section of the Explosives Act, 1875.

Low Tension Electric Detonator Fuses, consisting of low tension electric fuses as above described (*see* above in Division 2), and having the platinum wire embedded in a charge not exceeding two (2) grains of a priming composition consisting of (*a*) carefully purified gun-cotton, or (*b*) carefully purified collodion cotton, and the case being fitted with a detonator.

Low Tension Electric Detonator Fuses, consisting of a low tension electric fuse as above described (*see* above in Division 2), and having attached thereto a detonator.

Spon's Electric Detonator Fuses, consisting of Spon's Electric Fuses as above described (*see* above in Division 2), and having attached thereto a detonator as defined by an Order in Council made under the 106th section of the Act.

Fuses for Shell, consisting of cases of wood or metal, or other suitable material, charged or primed with fuse or other suitable composition, containing their own means of ignition, and of such strength and construction that the explosion of one fuse will not communicate the explosion to other like fuses.

Colliery Safety Lighters, consisting of a tube of metal, millboard, or other suitable material, closed at one end, and containing sulphuric acid enclosed in a glass globule or tube embedded in or contiguous to a mixture of chlorate of potassium and sugar (whether or not contained in an inner metallic tube, containing or not containing gunpowder), and with or without the addition of a piece of safety-fuse. Provided that the amount of the mixture aforesaid contained in any one of the said colliery safety lighters shall not exceed five (5) grains. Provided also that the said colliery safety lighters shall be of such strength and construction that the ignition of one such colliery safety lighter will not communicate laterally with others.

Detonators, consisting of a capsule or case of such strength and construction, and containing an explosive of the fulminate class in such quantity, that the explosion of one capsule or case will communicate the explosion to other like capsules or cases. *O. in C., No.* 1.

Tubes for Firing Explosives (other than to Detonators), consisting of cases of quill, metal, or paper, charged with mealed powder or other suitable explosive, and containing their own means of ignition.

Elswick Mechanical Tubes, consisting of a case of metal, wood, paper, or other suitable material, containing its own means of ignition and a charge not exceeding 1 ounce of gunpowder.

Safety Firing Tubes, No. 2, consisting of Safety Firing Tubes, No. 1 (*see* above in Division 1), with the addition of a priming charge of meal powder not exceeding 40 grains. The whole to be of such construction that the explosion of one will not communicate to others in close contact.

VII.—FIREWORKS.

Division 1.

Firework Composition, consisting of any chemical compound or mechanically mixed preparation of an explosive or inflammable nature which is used for the purpose of making manufactured fireworks, and is not included in the former classes of explosives, and also any coloured fire composition. *O. in C., No.* 1.

Division 2.

Amorces (whether in the form of toy caps or igniting tapes), consisting of dots of one or other of the undermentioned compositions enclosed between two pieces of paper, or separated by a sheet of paper or cardboard, in a proportion not exceeding seventy (70) grains of such composition to every one thousand (1,000) dots.

> Composition (*a*): A mixture of chlorate of potassium and amorphous phosphorus, with or without the addition of (1) nitrate of potassium, sulphide of antimony, and powdered sulphur (free from acid); or (2) chalk, rye, flour, and resin (sandarak); or (3) manganese and glue; or (4) such other substance as may from time to time be approved by the Secretary of State: provided that the amount of amorphous phosphorus present in the mixture shall in no case exceed the proportion of ten (10) grains in one thousand (1,000) dots.
>
> Composition (*b*): A mixture of chlorate of potassium and ferrocyanide of lead.

Crack Shots, consisting of an amorce composed of a patch of thoroughly purified fulminate of silver enclosed between two pieces of paper in a proportion not exceeding fifteen (15) grains of such fulminate of silver to every one thousand (1,000) amorces, such amorce to be gummed to or form part of a sheet of paper not less than four (4) inches square, and having a strip impregnated with nitre.

Manufactured Fireworks, consisting of any explosive of the foregoing classes, and any firework composition, when such explosive or composition is enclosed in any case or contrivance, or is otherwise manufactured so as to form a squib, cracker, serpent, rocket (other than a war rocket), maroon, star, lance, wheel, Chinese fire, Roman candle, or other article adapted for the production of pyrotechnic effects or pyrotechnic signals. *O. in C.*, *No.* 1.

Oriental Fireworks, consisting of a mixture of saltpetre, sulphur, and charcoal, enclosed in a paper or bamboo case, with or without the addition of a mixture of realgar and chlorate of potash: provided that the amount of such mixture of realgar and chlorate of potash shall not exceed two (2) grains in any one firework.

Socket Sound Signals, consisting of a case of tinned iron, containing one or more charges of tonite or cotton powder as hereinafter described, such charges not exceeding together eight (8) ounces, and having inside the base of the said case, or attached to the exterior thereof in a case or bag of india-rubber, canvas, or other suitable material, a charge of gunpowder not exceeding two and a half (2½) ounces; the charges of tonite and gunpowder being connected by means of a suitable time fuse of wood, copper, or tinned iron, in communication or connection with a detonator as defined by an Order in Council made under the 106th section of the said Act, such detonator to contain above the fulminate a substantial layer of strongly compressed mealed gunpowder, and being itself embedded in tonite, the said tonite to consist of gun-cotton thoroughly purified, mixed or impregnated with a nitrate or nitrates.

Socket Distress Signals, consisting of a socket sound signal as above described, in the upper part thereof a star or stars composed of two or more of the following ingredients, viz., saltpetre, sulphur (carefully washed), realgar, antimony, gunpowder; or one or more stars of the following composition, viz., *Red Stars*, consisting of nitrate of strontia, chlorate of potash, charcoal, and shellac, incorporated with shellac solution, and with or without the addition of gun-cotton thoroughly purified, not exceeding 10 per cent. by weight of the finished stars; *Green Stars*, consisting of nitrate of baryta, chlorate of potash, charcoal, and shellac, incorporated with shellac solution, and with or without the addition of gun-cotton thoroughly purified, not exceeding 10 per cent. by weight of the finished stars; *White Stars*, consisting of nitrate of potash, sulphur (carefully washed), sulphide of antimony, realgar, gunpowder, and magnesium, incorporated with shellac solution, and with or without the addition of gun-cotton, thoroughly purified, not exceeding 10 per cent. by weight of the finished stars. Provided that each star may have a strand not exceeding five (5) grains in weight of thoroughly purified nitro-cellulose attached to and passing through it.

Sound Signal Rockets, consisting of a signal rocket, having fitted in the head thereof one or more charges of tonite or cotton powder as hereinafter described, and with or without a layer of compressed gunpowder made of sulphur free from acid, saltpetre, and charcoal between the said charges, and having embedded in the said charges one or more detonators as defined by an Order in Council made under the 106th section of the said Act, such detonators to contain above the fulminate a substantial layer either of strongly compressed mealed gunpowder, or a composition made of two or more of the following ingredients, viz., saltpetre, sulphur (carefully washed), realgar, antimony, gunpowder; the said tonite to consist of gun-cotton thoroughly purified, mixed or impregnated with a nitrate or nitrates.

Socket Light Signals, consisting of a case of tin or other suitable material, containing one or more white or coloured stars of the compositions hereinafter specified, and having attached to the base of the said case in a case or bag of indiarubber, canvas, or other suitable material, a charge of gunpowder not exceeding 2½ ounces, the said stars and gunpowder being connected by means of a suitable time fuse of wood, copper, tinned iron, or other suitable material. Provided that the total weight of the star or stars contained in any one signal shall not exceed 8 ounces. *Red Stars*, consisting of nitrate of strontia, chlorate of potash, charcoal, and shellac, incorporated with shellac solution, with or without the addition of gun cotton thoroughly purified, not exceeding 10 per cent. by weight of the finished stars. *Green Stars*, consisting of nitrate of baryta, chlorate of potash, charcoal, and shellac, incorporated with shellac solution, with or without the addition of gun-cotton thoroughly purified, not exceeding 10 per cent. by weight of the finished stars. *White Stars*, consisting of nitrate of potash, sulphur (carefully washed), sulphide of antimony, realgar, gunpowder, and magnesium, incorporated with shellac solution, with or without the addition of gun-cotton thoroughly purified, not exceeding 10 per cent. by weight of the finished stars. Provided that each star may have a strand not exceeding five (5) grains in weight of thoroughly purified nitro-cellulose attached to or passing through it.

Distress Signal Rockets, consisting of sound signal rockets as above described (*see* Class 6, Division 3), with the addition in the head of the rocket of one or more stars composed of two or more of the following ingredients, viz., saltpetre, sulphur (carefully washed), realgar, antimony, gunpowder.

Throwdowns.	Licensed as "Toy Fireworks."
Snaps for Bonbon Crackers.	

Magic Candle Pin Crackers, consisting of thoroughly purified fulminate of silver, gummed, or otherwise attached to a pin, and protected by a coating of paper, in a proportion not exceeding fifteen (15) grains of such fulminate of silver to every one thousand (1,000) magic candle pin crackers.

N.B.—It is a condition of the license that these crackers shall be packed in numbers not exceeding twelve in stout paper, and each such package placed singly in a box of wood or cardboard, properly secured against escape of explosive; such boxes to be further packed as required for fireworks.

Coloured Fires.

These are used in fireworks and illuminations, and consist of oxidising agents, such as chlorate of potash or nitrates of the alkalies, together with an easily combustible material such as sulphur, and small quantities of certain chemicals or minerals to give the lights a variety of colours. These goods are highly inflammable, and when confined are more or less explosive.

The following list shows the percentage composition of the more important coloured fires used :—

Red Fire.

Nitrate of Strontia	40	per cent.
Sulphur	13	,,
Chlorate of Potash	5	,,
Charcoal or Lampblack	3	,,
Sulphide of Antimony	4	,,

Green Fire.

Nitrate of Baryta	77	per cent.
Sulphur	13	,,
Chlorate of Potash	5	,,
Charcoal or Lampblack	3	,,
Metallic Arsenic	2	,,

White Indian Fire.

Nitrate of Potash	73	per cent.
Sulphur	20	,,
Sulphide of Arsenic	7	,,

Purple Fire.

Chlorate of Potash	43	per cent.
Nitrate of Potash	22½	,,
Sulphur	22½	,,
Black Oxide of Copper	10	,,
,, Sulphide of Mercury	2	,,

Crimson Fire.

Nitrate of Strontia	53	per cent.
Sulphur	22	,,
Chlorate of Potash	20	,,
Charcoal or Lampblack	5	,,

Blue or Bengal Fire.

Nitrate of Potash	66	per cent.
Sulphur	22	,,
Tersulphide of Antimony	12	,,

Lilac Fire.

Chlorate of Potash	49	per cent.
Sulphur	25	,,
Chalk	20	,,
Black Oxide of Copper	6	,,

Yellow Fire.

Nitrate of Soda	75	per cent.
Sulphur	19	,,
Charcoal or Lampblack	6	,,

THE EXPLOSIVES ACT, 1875.

(38 Vict. c. 17.)

In the following abstract of this enactment, either the substance or (in many cases) the full text is given of those portions of the Act which it will be useful for manufacturers, vendors, and users of explosives, or importers or carriers of those substances, to have at hand for reference.

The Act—which is intituled, "An Act to amend the Law with respect to manufacturing, keeping, selling, carrying, and importing Gunpowder, Nitro-glycerine, and other explosive substances"—was passed 14th June 1875, and came into operation on 1st January 1876. There is no occasion to notice here those sections of the Act which made temporary provision concerning factories or stores for explosives existing when the Act was passed and authorised under previous Acts; and the provisions of the Act (Part I.) which relate to gunpowder will be set out here in those cases only in which the same provisions are subsequently applied by the Act (Part II.) to high explosives.

In many of its provisions, the requirements of the Act are not easily followed, but on this point the remarks of Sir Frederick Abel will commend themselves:—"It can hardly be doubted that the somewhat complicated machinery of the Act, found necessary in the first instance in order to attain an efficient control over the making, carriage, keeping, &c., of all explosive substances in their great variety of forms and applications, from barrels of powder and ship-loads and stores of dynamite, ammunition, and detonators, to drawing-room fireworks, substitutes for pigeon-shooting, and toy crackers, will in due course be much simplified. There can be no doubt that the action of manufacturers and vendors themselves will importantly contribute (and has, indeed, already to some extent contributed) to such simplification, not by their raising difficulties and entertaining or conniving at attempts of evasion, but by their ready adoption of obviously wise precautions and improvements, and by the systematic exercise of care and vigilance within their individual spheres of influence."

Definition of Explosive.

In the Act the term "explosive" is defined to mean gunpowder, nitro-glycerine, dynamite, gun-cotton, blasting powders, fulminate of mercury or of other metals, coloured fires, and "every other substance, whether similar to those above mentioned or not, used or manufactured with a view to produce a practical effect by explosion or a pyrotechnic effect;" and it also includes fog-signals, fireworks, fuses, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, and "every adaptation or preparation of an explosive as above defined" (s. 3).

Scope of the Act.

By the Act, various powers for the control of the manufacture of explosives, and of all trafficking therein, are vested in (1) the Secretary of State (*i.e.*, in practice, the Home Secretary), who is authorised to appoint Government Inspectors of Explosives; (2) in the Local Authorities defined by the Act; and (3) in Harbour Authorities. For the effective administration of the Act, large powers of search and inquiry are given to the Government Inspectors, and (in a lesser degree) to officers of Local Authorities. Breaches of law under the Act—whether of its express provisions or of rules or bye-laws framed under it—render the offenders liable to heavy and summary penalties, and these will be found mentioned in the following pages in every case specified in the Act. Where exception may be taken by the occupier of premises licensed under the Act to the requisitions made by a Government Inspector, provision is made by the Act for a reference of the matter in dispute to arbitration. Special provision is also made for official inquiry into accidents occurring with explosives not only in a factory, magazine, or store licensed under the Act, but on any "carriage, ship, or boat" used for conveying explosives; and special regulations are required to be observed at coroners' inquests on deaths resulting from accidents with explosives.

Local Authorities.

The Local Authorities for the purposes of the Act are—

In England (s. 67),

(1.) In the City of London, the court of the Lord Mayor and Aldermen;
(2.) In the Metropolis outside the City of London, the Metropolitan Board of Works;* and
(3.) In any borough not assessed to the county rate by the county justices, the Mayor, Aldermen, and Burgesses acting by the Council; but
(4.) In any harbour within the jurisdiction of a harbour authority, whether situate or not within the jurisdiction of any local authority before mentioned, the Harbour Authority, to the exclusion of any other local authority; and
(5.) In any place in which there is no local authority as above the Justices in petty sessions assembled.*

By s. 68 the Secretary of State is empowered to declare the Council of a borough assessed to the county rate, and the Improvement Commissioners of a district, to be Local Authorities (but not for a harbour) under the Act.

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* By the Local Government Act, 1888, the powers, duties, and liabilities of the Metropolitan Board of Works were transferred to the London County Council (51 & 52 Vict. c. 41, ss. 40-45); and by the same Act (s. 7) the business of county justices as Local Authorities under the Explosives Act was transferred to County Councils.

In Scotland (s. 110),

(1.) In any borough the Magistrates and Town Council;
(2.) In any harbour within the jurisdiction of a harbour authority, whether situate or not within the jurisdiction of any local authority for a borough, the Harbour Authority, to the exclusion of any other local authority;
(3.) In any place other than a borough or harbour the County Justices.

But by s. 115, the Secretary of State is empowered to declare the Police Commissioners of a burgh to be the Local Authority in certain cases.

In Ireland (s. 116),

(1.) In the City of Dublin, the Lord Mayor, Aldermen, and Burgesses acting by the Town Council; and
(2.) In an urban sanitary district, the Urban Sanitary Authority; but
(3.) In any harbour within the jurisdiction of a harbour authority, whether situate or not within the jurisdiction of any local authority above mentioned, the Harbour Authority, to the exclusion of any other local authority;
(4.) In any place in which there is no local authority as above defined, the Justices in petty sessions.

The expression Harbour Authority in the Act includes (s. 107) any person or body of persons claiming to be proprietor or proprietors of or intrusted with the duty or power of maintaining or regulating any harbour, and any port, haven, and estuary, or intrusted with the duty of conserving the navigation of any tidal water; and any such harbour, port, haven, estuary, tidal water, and any wharf, dock, pier, jetty, and work, and other area, whether land or water, over which the Harbour Authority have control or exercise powers, are included in the Act in the expression "harbour."

PART I.—GUNPOWDER.

Part I. of the Act comprises the sections relating to gunpowder, and contains the following provisions, these being made applicable (with certain modifications and additions) to other explosives also in subsequent sections (Part II.) of the Act :—

Manufacture and Keeping of Gunpowder.

The manufacture of gunpowder shall not, nor shall any process of such manufacture, be carried on except at a factory for gunpowder either lawfully existing or licensed under the Act; and any person who carries on any such process of manufacture, except as allowed by the Act, shall be deemed to manufacture gunpowder at an unauthorised place.

Where gunpowder is manufactured at an unauthorised place, (1) all or any part of the gunpowder or ingredients of gunpowder found in or about such place may be forfeited, and the person so manufacturing shall be liable to a penalty of £100 for every day during which he so manufactures (s. 4).

Gunpowder, unless kept for private use and not for sale to an amount not exceeding thirty pounds, or in the keeping of a carrier for the purpose of conveyance in accordance with the provisions of the Act, shall not be kept at any place except in the factory in which it is manufactured; or (2) in a magazine or store either lawfully existing or licensed under the Act, or (3) in premises registered under the Act. Where gunpowder is kept in an unauthorised place, all or any part of the gunpowder found in such place may be forfeited; and the occupier of such place, and also the owner of, or other person guilty of keeping the gunpowder, shall each be liable to a penalty of 2s. for every pound of gunpowder so kept (s. 5).

Licensing of Factories and Magazines.

A new factory or magazine for gunpowder shall not be established except on the site and in the manner specified in a license to be granted by the Secretary of State, with the assent of the Local Authority. Detailed directions are given in the Act for obtaining such license and the requisite assent of the Local Authority (ss. 6, 7, 8).

Regulation of Factories and Magazines.

In every gunpowder factory and magazine—

(1.) The factory or magazine, or any part thereof, shall not be used for any purpose not in accordance with the license; and

(2.) The terms of the license shall be duly observed, and the manufacture or keeping or any process in or work connected with the manufacture or keeping of gunpowder shall not be carried on except in accordance with those terms; and

(3.) The factory or magazine and every part thereof shall be maintained in accordance with the license; and any material alteration in the factory or magazine by enlarging or adding to the site, or by externally enlarging or adding to any building, or by altering any mound otherwise than by enlargement, or by making any new work, shall not be made except in pursuance of an amending license granted under the Act.

In the event of any breach (by any act or default) of this section, the gunpowder or ingredients thereof in respect to which, or being in any building or machine in respect to which, the offence was committed, may be forfeited; and the occupier shall be liable to a penalty not exceeding in the case of the first offence £50, and in the case of a second or any subsequent offence £100, and in addition £50 for every day during which such breach continues (s. 9).

The occupier of a factory shall not be deemed guilty of a breach of this section for using in a case of emergency, or temporarily, one building or part of a building in which any process of the manufacture is, under the terms of the license, carried on, for another process of the manufacture, if he do not carry on in such building or part more than one process at the same time, and if the quantity of gunpowder or ingredients thereof in such building or part do not exceed the quantity allowed to be therein, or any less quantity allowed to be in the building or part of a building in which such other process is usually carried on; and if upon such use being continued after the lapse of twenty-eight days from the first beginning of such use he send notice to a Government Inspector, and the Inspector do not require its discontinuance (s. 9).

In the event of any breach (by any act or default) in any factory or magazine of the general rules for gunpowder factories prescribed by the Act,* all or any part of the gunpowder or ingredients thereof in respect to which, or being in any building or machine in respect to which, the offence was committed, may be forfeited; and the occupier shall be liable to a penalty not exceeding £10, and in addition (on a second offence) £10 for every day during which such breach continues (s. 10).

Every occupier of a gunpowder factory or magazine shall, with the sanction of the Secretary of State, make special rules for the regulation of the persons employed therein, and there may be annexed to any breach of such special rules penalties not exceeding 40s. for each offence (s. 11).

Supplemental as to Factories and Magazines.

Where the occupier of a gunpowder factory or magazine desires that any alteration should be made in the terms of his license, or any material alteration made in the factory or magazine by enlarging or adding to the site or by externally enlarging or adding to any building, or by altering any mound otherwise than by enlargement, or by making any new work, he may apply for an amending license. If he satisfy the Secretary of State that the alteration may be properly permitted without increased risk, the Secretary of State may grant the amending license of his own authority, but otherwise the application will be dealt with as an application for a new license (s. 12).

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* The "general rules" of sect. 10 are omitted here, as not concerning factories for high explosives (see *post*, p. 198).

A gunpowder factory or magazine license shall not be avoided by any change in the occupier of the factory or magazine; but notice of the name, address, and calling of the new occupier shall be sent to the Secretary of State within three months after the change, and in default such new occupier shall be liable to a penalty not exceeding 20s. for every week during which such default continues (s. 13).

Stores for Gunpowder.

Any person may apply to the Local Authority for a license for a gunpowder store, and if the proposed site, construction of the store, and amount of gunpowder to be stored therein are in accordance with the Order in Council (*see* s. 16), the license is to be granted on payment of a fee not exceeding 5s. (s. 15).

Her Majesty may from time to time, by Order in Council, regulate the construction and materials and fittings of gunpowder stores, prescribe the buildings and works from which gunpowder stores are to be separated, and the distances by which they are to be separated; and prescribe the maximum amount of gunpowder, not exceeding 2 tons, to be kept in stores, graduated according to their construction and situation and their distance from the said buildings and works (s. 16).

In the event of any breach (by any act or default) of the general rules prescribed by the Act for gunpowder stores, all or any part of the gunpowder in respect to which or being in the store when the offence was committed may be forfeited, and the occupier shall be liable to a penalty not exceeding £10, and in addition (on a second offence) £10 for every day during which such breach continues (s. 17).

A store license shall be valid only for the person named in it, and shall be annually renewed by the Local Authority, at a fee not exceeding 1s., and unless so renewed shall expire (s. 18).

Every occupier of a gunpowder store may, with the sanction of the Secretary of State, make special rules for the regulation of the persons employed therein, and there may be annexed to any breach of such special rules penalties not exceeding 40s. for each offence (s. 19).

Registered Premises.

A person desirous of registering with the Local Authority any premises for the keeping of gunpowder shall register his name and calling, as well as the premises, in such manner and on payment of such fee, not exceeding 1s., as may be directed by the Local Authority, such registration to be annually renewed at a fee not exceeding 1s.

In the event of any breach (by any act or default) of the general rules prescribed by the Act for registered premises, all or any part of the gunpowder in respect to which, or being in any house, building, place, safe, or receptacle in respect to which, the offence was committed, may be forfeited, and the occupier shall be liable to a penalty not exceeding 2s. for every pound of gunpowder in respect of which or being on the premises in which the offence was committed (s. 22).

Supplemental Provisions.

The occupier of every factory, magazine, store, and registered premises for gunpowder, and every person employed in or about the same, shall take all due precaution for the prevention of accidents by fire or explosion, and for preventing unauthorised persons having access thereto or to the gunpowder therein, and shall abstain from any act whatever which tends to cause fire or explosion and is not reasonably necessary for the work therein; and any breach (by any act or default) of this section shall be deemed to be a breach of general rules (s. 23).

The Local Authority shall cause registers to be kept of all store licenses granted by and of all premises registered with them under the Act; and a ratepayer within the area of the Local Authority, or a licensee or person registered under the Act, upon payment of a fee of 1s., and a Government inspector, or an officer appointed by any Local Authority for the purposes of the Act, or an officer of police, without payment, shall be entitled at all reasonable times to inspect and take extracts from any such registers (s. 28).

If the occupier of a store or registered premises dies or becomes bankrupt, or has his affairs liquidated by arrangement, or becomes mentally incapable or otherwise disabled, the person carrying on the business of such occupier shall not be liable to any penalty for acting under the license or registration during such reasonable time as may be necessary to allow him to obtain a fresh license or registration (s. 29).

Sale of Gunpowder.

Gunpowder shall not be hawked, sold, or exposed for sale upon any highway, street, public thoroughfare, or public place; and (1) any person hawking, selling, or exposing gunpowder for sale shall be liable to a penalty not exceeding 40s., and (2) all or any part of the gunpowder so hawked or exposed for sale, or found in the possession of any person convicted hereunder, may be forfeited (s. 30).

Gunpowder shall not be sold to any child apparently under the age of thirteen years; and any person selling gunpowder in contravention of this section shall be liable to a penalty not exceeding £5 (s. 31).

All gunpowder exceeding one pound in weight, when publicly exposed for sale or sold, shall be in a substantial case, bag, canister, or other receptacle made and closed so as to prevent the gunpowder from escaping, and to such outermost receptacle shall be affixed the word "gunpowder" in conspicuous characters by means of a brand or label, or other mark; and if any gunpowder is sold or exposed for sale in contravention of this section, the person offending shall be liable to a penalty of 40s., and all or any part of the gunpowder so exposed for sale may be forfeited (s. 32).

Conveyance of Gunpowder.

The following general rules shall be observed with respect to the packing of gunpowder for conveyance :—

(1.) The gunpowder, if not exceeding five pounds in amount, shall be contained in a substantial case, bag, canister, or other receptacle, made and closed so as to prevent the gunpowder from escaping ; and

(2.) The gunpowder, if exceeding five pounds in amount, shall be contained either in a single package or a double package. A single package shall be a box, barrel, or case of such strength, construction, and character as may be for the time being approved by the Government inspector as being of such strength, construction, and character that it will not be broken or accidentally opened, or become defective or insecure whilst being conveyed, and will not allow the gunpowder to escape. If the gunpowder is packed in a double package, the inner package shall be a substantial case, bag, canister, or other receptacle made and closed so as to prevent the gunpowder from escaping, and the outer package shall be a box, barrel, or case of wood or metal or other solid material, and shall be of such strength, construction, and character that it will not be broken or accidentally opened, or become defective or insecure whilst being conveyed, and will not allow the gunpowder to escape ; and

(3.) The interior of every package, whether single or double, shall be kept free from grit and otherwise clean ; and

(4.) Every package, whether single or double, when actually used for the package of gunpowder, shall not be used for any other purpose ; and

(5.) There shall not be any iron or steel in the construction of any such single package or inner or outer package, unless the same is effectually covered with tin, zinc, or other material ; and

(6.) The amount of gunpowder in any single package, or if there is a double package, in any one outer package, shall not exceed one hundred pounds, except with the consent of and under conditions approved by a Government Inspector ; and

(7.) On the outermost package there shall be affixed the word "gunpowder" in conspicuous characters by means of a brand or securely attached label or other mark.

In the event of any breach (by any act or default) of any of the above-mentioned general rules, the gunpowder in respect of which the breach is committed may be forfeited, and the person guilty of such breach shall be liable to a penalty not exceeding £20.

The general rules contained in this section may from time to time be altered by the Secretary of State (s. 33).

Bye-Laws.

Every Harbour Authority shall, with the sanction of the Board of Trade, make bye-laws for regulating the conveyance, loading, and unloading of gunpowder within its jurisdiction.

For breaches of such bye-laws, penalties are authorised by the Act, not exceeding £20 for each offence, and £10 for each day during which the offence continues, besides forfeiture of all or any part of the gunpowder in respect of which, or found in the ship, boat, or carriage in respect of which, the breach of bye-law has taken place (s. 34).

Any person resisting a harbourmaster or officer acting under such bye-laws shall be liable to the same penalties as a person for obstructing the harbourmaster in the execution of his duty (s. 34).

On any part of the coast of the United Kingdom, or in any tidal water for which there is no harbour authority, the Board of Trade are empowered by the Act to make bye-laws for that part or water as if it were a harbour and they were the harbour authority; and they may by such bye-laws define the area within which they are to be observed, and the officers by whom they are to be enforced (*ibid.*).

Every railway or canal company over whose railway or canal any gunpowder is to be carried, shall, with the sanction of the Board of Trade, make bye-laws for regulating the conveyance, loading, and unloading of such gunpowder (s. 35).

Penalties for any breach of any such bye-laws may be imposed, and may be graduated according to the gravity of the offence, and according as it may be a first, second, or other subsequent offence, that is to say, pecuniary penalties not exceeding £20 for each offence, and £10 for each day during which the offence continues, besides forfeiture of all or any part of the gunpowder in respect of which, or being in the carriage, ship, or boat or train of carriages, ships, or boats in respect of which, the breach of bye-law has taken place (*ibid.*).

The occupier of every wharf or dock on or in which gunpowder is loaded or unloaded (if such loading or unloading is not otherwise subject to any bye-laws under this Act) may, and if so required by the Secretary of State shall, from time to time, with the sanction of the Secretary of State, make bye-laws for regulating the loading and unloading of gunpowder on or in such wharf or dock, and in particular for declaring or regulating all or any of the matters which can be declared or regulated in the case of any wharf or dock within the jurisdiction of a harbour authority by bye-laws made by such authority in pursuance of this Act; and penalties may be annexed to breaches of such bye-laws, as in the case of bye-laws made under section 35 (s. 36).

The Secretary of State is empowered to make bye-laws for regulating the conveyance, loading, and unloading of gunpowder by land or otherwise, in any case in which bye-laws made under any other provision of the Act do not apply; and penalties may be annexed to any breach of any such bye-laws as in the case of bye-laws made under section 35 (s. 37).

Any recommendation to Her Majesty in Council, any general rules with respect to packing, and any bye-laws which is or are proposed to be made under the Act by a Secretary of State or the Board of Trade shall, before being so made, be published in such manner as the Secretary of State or the Board of Trade may direct; and the bye-laws framed by any Railway Company, Canal Company, or Harbour Authority under the Act shall, before being sanctioned by the Board of Trade, be likewise published in such manner as the Board may direct (s. 38).

PART II.—EXPLOSIVES OTHER THAN GUNPOWDER.

Part II. of the Act relates to explosives other than gunpowder, and by s. 39 it is declared that, subject to the provisions hereafter in this part of the Act contained, Part I. of the Act relating to gunpowder shall apply to every other description of explosive, in like manner as if those provisions were re-enacted with the substitution of that description of explosive for gunpowder.

Modification of Part I. as applied to Explosives other than Gunpowder.

In the case of explosives other than gunpowder, the following modifications and additions are to be made in and to Part I. of the Act:—

(1.) The draft license for a factory or magazine submitted by an applicant to the Secretay of State shall specify such particulars as the Secretary of State may require;

(2.) The prescribed general rules [*i.e.*, rules prescribed by an Order in Council] shall be substituted for the general rules in Part I. of the Act relating to factories, magazines, stores, and registered premises respectively; but no such general rule shall require the removal of any building or work in use at the date of the Order in Council by which such rule is made;

(3.) The Secretary of State may from time to time alter the general rules relating to packing contained in Part I. of the Act for the purpose of adapting the same to the packing of any explosive other than gunpowder; and

(4.) For the maximum amount limited by the Act to be kept for private use and not for sale, or in a store, and for the minimum amount limited by the Act to be exposed for sale or sold otherwise than in a substantial case, box, canister, or other receptacle as therein mentioned, there shall be substituted in the case of explosives other than gunpowder the following amounts; namely, (*a*) where such explosive consists of safety cartridges made with gunpowder, an amount containing not more than five times the maximum or minimum amount of gunpowder, as the case may be, above mentioned; and (*b*) in the case of any other explosive, the prescribed amount; and

(5.) Two or more descriptions of explosives shall not be kept in the same store or registered premises, except such descriptions as may be prescribed in that behalf; and, when so kept, shall be kept subject to the prescribed conditions and restrictions; and

(6.) Where any explosive, other than gunpowder, is allowed to be kept in the same store or registered premises with gunpowder, the maximum amount of gunpowder to be kept therein shall be the prescribed amount in lieu of the amount fixed by Part I. of the Act; and

(7.) Where any explosive other than gunpowder is allowed to be kept in the same magazine, store, or registered premises with gunpowder, the prescribed general rules shall be observed instead of the general rules set out in the Act; and

(8.) There shall be on the outermost package containing the explosive, in lieu of the word "gunpowder," the name of the explosive, with the addition of the word "explosive," and if such name is materially false the person selling or exposing for sale such explosive, and also the owner of the explosive, shall be liable to a penalty not exceeding £50.

(9.) With respect to the importation from any place out of the United Kingdom of either dynamite or gun-cotton, or any explosive (other than gunpowder, cartridges made with gunpowder, percussion caps, fireworks, and any prescribed explosive), the following provisions shall have effect:—(*a*) The owner and master of any ship having on board any such explosive shall not permit the same to be unloaded and delivered to any person who does not hold an importation license from the Secretary of State, and any transhipment shall be deemed to be delivery; (*b*) the Secretary of State may grant an importation license for any such explosive, and may annex thereto such provisions and restrictions as he may think fit for the protection of the public from danger; (*c*) the license shall be of such duration as the Secretary of State may fix, and shall be available only for the person named in the license; (*d*) in the event of any breach by any act or default of the provisions of this section with respect to the importation of an explosive, or of the provisions of any importation license, all or any part of the explosive with respect to which such breach is committed, or being in any ship or boat in connection with which such breach is committed, may be forfeited, and the

> owner and master of such ship or boat, and the licensee or person to whom the explosive is delivered, shall each be liable to a penalty not exceeding £100, and to a further penalty not exceeding 2s. for every pound of such explosive; and (*e*) the Commissioners of Customs and their officers shall have the same power with respect to any such explosive, and the ship containing the same, as they have for the time being with respect to any article on the importation of which restrictions are for the time being imposed by law (s. 40).

Nothing in the Act shall apply to the filling or conveying, for private use and not for sale, of any safety cartridges to the amount allowed by the Act to be kept for private use (s. 41).

Sect. 29 of the Passengers Act, 1855,* and sects. 23 to 27, both inclusive, of the Merchant Shipping Act, 1873,† shall apply to every explosive within the meaning of this Act in like manner as they apply to gunpowder (s. 42).

Specially Dangerous Explosives.

Her Majesty from time to time, by Order in Council, may prohibit, either absolutely, or except in pursuance of a license of the Secretary of State under this Act, or may subject to conditions or restrictions the manufacture, keeping, importation from any place out of the United Kingdom, conveyance, and sale, or any of them, of any explosive which is of so dangerous a character that it is expedient for the public safety to make such Order; and any explosive manufactured or kept in contravention of any such Order shall be deemed to be manufactured or kept in an unauthorised place, and any explosive conveyed in contravention of any such Order shall be deemed to be conveyed in contravention of a bye-law under the Act.

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* By which gunpowder is prohibited as cargo on a passenger ship.

† Imposing a penalty of £500 on any person who sends by ship "dangerous goods" under a false description, and empowering the shipowner or master to throw such goods overboard, and declaring dangerous goods so sent liable to forfeiture.

If any explosive is imported or sold in contravention of any such Order, (1) all or any part of such explosive may be forfeited; (2) the owner or master of the ship in which it was imported shall be liable to a penalty not exceeding 10s. for every pound of such explosive brought in the ship; and (3) the person to whom it was delivered and the person selling the same shall be liable to a penalty not exceeding 10s. for every pound of such explosive delivered or sold or found in his possession.

The Commissioners of Customs and their officers shall have the same power with respect to any such explosive, and the ship containing the same, as they have for the time being with respect to any article prohibited by law to be imported (s. 43).

Provisions in favour of certain Manufacturers and Dealers.

The occupier of a factory for any explosive shall not be required to take out a factory license for making up on such factory the explosive made thereon into cartridges or charges for cannon or blasting not containing within themselves their own means of ignition; and the occupier of any magazine, store, or registered premises for keeping any explosive may keep such explosive when so made up into cartridges or charges as if it were not so made up (s. 44).

The occupier of a factory for any explosive who manufactures a new form of explosive similar to the one specified in his license, shall not be deemed to have manufactured the same in an unauthorised place if the manufacture be on a small scale, and exclusively for the purpose of trial and not for sale, and if he send notice thereof as soon as manufactured to the Secretary of State (s. 45).

The occupier of a magazine, store, or registered premises for any explosive shall not be required by the Act to take out a factory license by reason that in connection with such magazine, store, or premises he fills for sale or otherwise any cartridge for small arms with the said explosive, so that he observe the following regulations; namely,

(1.) There shall not be in the room in which such filling is being carried on more than five pounds of gunpowder, or the prescribed amount of any other explosive, except it is made up into safety cartridges; and

(2.) Any work unconnected with the making of the cartridges shall not be carried on in the room while such filling is being carried on; and

(3.) There shall not be in the room while such filling is being carried on any fire nor any artificial light, except a light of such construction, position, or character as not to cause any danger of fire or explosion; and

(4.) In the case of a magazine or store, the room in which the filling is carried on shall be detached from the magazine or store, but in the immediate neighbourhood thereof, and at such distance therefrom as may be specified in the case of a magazine by the license, and in the case of a store by an Order in Council relating to stores; and

(5.) The occupier shall give notice in the case of a magazine to the Secretary of State, and in the case of a store or registered premises to the Local Authority, that he intends to carry on such filling of cartridges.

In the case, however, of magazine or store for which a continuing certificate has been obtained, the previous consent of the Secretary of State will be required.

The regulations in this section shall be deemed to be general rules under the Act, and the breach of them shall be punished accordingly (s. 46).

The occupier of any magazine or store for any explosive shall not be required by the Act to take out a factory license by reason that, in connection with such magazine or store, he, by filling cartridges, making charges, drying, sifting, fitting, or otherwise, adapts or prepares the said explosive for use exclusively in his mine or quarry, or in some excavation or work carried on by him or under his control, so that he observe the following regulations; namely,

(1.) There shall not be in the workshop in which such adaptation or preparation is carried on more than 100 pounds of gunpowder or the prescribed amount of any other explosive; and

(2.) Any work unconnected with such adaptation or preparation shall not be carried on in the said workshop while such adaptation or preparation is being carried on; and

(3.) The said workshop shall be detached from the magazine or store, but in the immediate neighbourhood thereof, and at such distance therefrom as may be specified, in the case of a magazine by the license, and in the case of a store by an Order in Council relating to stores; and

(4.) An explosive of one description shall not be converted into an explosive of another description, and shall not be unmade or resolved into its ingredients; and

(5.) The occupier shall give notice in the case of a magazine to the Secretary of State, and in the case of a store to the Local Authority, that he intends to carry on such adaptation or preparation as is allowed by this section.

In the case, however, of a magazine or store for which a continuing certificate has been obtained, the previous consent of the Secretary of State will be required.

The regulations in this section shall be deemed to be general rules under the Act, and the breach of them shall be punished accordingly (s 47).

Existing Factories, Magazines, and Stores.

In any continuing certificate for a lawfully existing factory or magazine for any explosive other than gunpowder, the following regulations are to form part of the terms of such certificate :—

(1.) If the factory or magazine is for dynamite or any substance having nitro-glycerine as one of its component parts or ingredients, the conditions contained in the existing license, with such modifications (if any) as the Secretary of State may think necessary in order to bring the same into conformity with this Act, and also any limitation of time for the expiration of the license contained in the existing license, and also the existing power of the Secretary of State to revoke the license ; and

(2.) In any other case, such terms as the Secretary of State may think expedient, having regard to the conditions (if any) contained in the license under which the factory or magazine is established ; and such terms shall include any limitation of time contained in such license, but shall not require the removal of any lawfully existing building or work (s. 51).

PART III.—ADMINISTRATION OF LAW.

Government Inspectors of Explosives.

A Government inspector shall have power to make such examination and inquiry as may be necessary to ascertain whether the Act is complied with, and for that purpose (1) he may enter, inspect, and examine any factory, magazine, or store of any explosive, and every part thereof, at all times by day and night, but so as not to unnecessarily impede or obstruct the work in such factory, magazine, or store, and may make inquiries as to the observance of the Act and all matters and things relating to the safety of the public or of the persons employed in or about such factory, magazine, or store; (2) he may enter, inspect, and examine any premises registered under this Act, and every part thereof, in which any explosive is kept, or is reasonably supposed by him to be kept, at all reasonable times by day; and (3) he may require the occupier of any factory, magazine, store, or premises which he is entitled, under this section, to enter, or a person employed by such occupier therein, to give him samples of any explosive or ingredients of an explosive therein, or of any substance therein, the keeping of which is restricted or regulated by the Act, or of any substance therein which the inspector believes to be an explosive, or such ingredients or substance.

The occupier of every such factory, magazine, store, and registered premises, his agents and servants, shall furnish the means required by the inspector as necessary for every such entry, inspection, examination, and inquiry.

Any person who obstructs an inspector in the execution of his duties under the Act shall be liable to a penalty of £100 for each offence (s. 55).

If in any matter not expressly provided for by the Act, an inspector find any factory, magazine, or store for an explosive, or any part thereof, or any thing or practice therein or connected therewith, to be unnecessarily dangerous or defective, so as in his opinion to tend to endanger the public safety or the bodily safety of any person, such inspector may require the occupier of such factory, magazine, or store to remedy the same; and where the occupier objects to comply with the requisition he may require the matter to be referred to arbitration in manner provided by the Act (s. 56).

Accidents.

Whenever there occurs any accident by explosion or by fire in or about or in connection with any factory, magazine, or store, or any accident by explosion or by fire causing loss of life or personal injury in or about or in connection with any registered premises, the occupier of such factory, magazine, store, or premises shall forthwith send or cause to be sent notice of such accident and of the loss of life or personal injury (if any) occasioned thereby to the Secretary of State. A notice of any accident of which notice is sent in pursuance of this section to a Government inspector need not be sent to any inspector or sub-inspector of factories or any inspector of mines.

Where in, about, or in connection with any carriage, ship, or boat, either conveying an explosive, or on or from which an explosive is being loaded or unloaded, there occurs any accident by explosion or by fire causing loss of life or personal injury, or if the amount of explosive conveyed or being so loaded or unloaded exceeds in the case of gunpowder half a ton, and in the case of any other explosive the prescribed amount, any accident by explosion or by fire, the owner or master of such carriage, ship, or boat, and the owner of the explosive conveyed therein or being loaded or unloaded therefrom, or one of them, shall forthwith send or cause to be sent notice of such accident, and of the loss of life or personal injury, if any, occasioned thereby, to the Secretary of State.

Every such occupier, owner, or master as aforesaid who fails to comply with this section shall be liable to a penalty of £20 (s. 63).

Where an accident by explosion or fire has occurred in, and wholly or partly destroyed a factory magazine, or any magazine or store, the factory magazine, magazine, or store shall not be reconstructed, and any further supply of an explosive shall not be put therein, except with the permission of the Secretary of State; and where an accident by explosion or fire in a factory has wholly or partly destroyed any building of such factory as to which a Government inspector has previously to the accident sent to the occupier a notice that the building is unduly near to some building or work outside the factory, such building shall be reconstructed only upon such site in the factory and with such precautions as may seem reasonable to the Secretary of State; and where an accident by explosion or by fire in a factory has wholly or partly destroyed two or more buildings in such factory, not more than one of such buildings shall be reconstructed except with the permission of the Secretary of State; provided that this enactment shall not apply to any buildings in a lawfully existing factory, if either both or all such buildings are incorporating mills, or if as regards any other buildings a Government inspector has not previously to the accident sent to the occupier a notice that such buildings are unduly near to each other. The reconstruction of any building in contravention of this section shall be deemed to be a breach of the terms of the license, and shall be punished accordingly (s. 64).

Coroners' Inquests.

Where a coroner holds an inquest upon a body of any person whose death may have been caused by any accident of which notice is required by the Act to be given to the Secretary of State, or by the explosion of any explosive, the coroner is to adjourn such inquest unless a Government nspector, or some person on behalf of the Secretary of State, is present to watch the proceedings; but if such accident or explosion has not occasioned the death of more than one person, and the coroner has sent to the Secretary of State not less than forty-eight hours' notice of the time and place of holding the inquest, it shall not be imperative on him to adjourn such inquest if the majority of the jury think it unnecessary; and where evidence is given at an inquest at which no Government inspector or official is present, of any neglect as having caused or contributed to the explosion or accident, or of any defect in or about or in connection with any factory, magazine, store, or registered premises, or any carriage, ship, or boat carrying an explosive, appearing to the coroner or jury to require a remedy, the coroner is to send to the Secretary of State notice in writing of such neglect or defect (s. 65).

Special Inquiries.

The Secretary of State may direct an inquiry to be made by a Government inspector into the cause of any accident which is caused by an explosion or fire either in connection with any explosive, or of which notice is required by the Act to be given to the Secretary of State; and where it appears to the Secretary of State, either before or after the commencement of any such inquiry, that a more formal investigation of the accident, and of the causes and circumstances thereof, is expedient, the Secretary of State is empowered to direct such an investigation to be held by a court having all the powers of a court of summary jurisdiction hearing informations for offences against the Act, as well as the powers of a Government inspector under the Act, and the special powers of entry and inspection of premises, of summoning witnesses, and of calling for books, papers, and documents, which are given by the Act (s. 66).

Powers of Officer of Local Authority.

Any officer authorised by the local authority may, on producing, if demanded, either a copy of his authority purporting to be certified by the clerk or some member of the local authority, or some other sufficient evidence of his authority, require the occupier of any store (not being subject to the inspection under the Act of any Inspector of Mines) or any registered premises, or any small firework factory, to show him every or any place and all or any of the receptacles in which any explosive or ingredient of an explosive, or any substance the keeping of which is restricted or regulated by the Act, that is in his possession is kept, and to give him samples of such explosive, ingredient, or substance, or of any substance which the officer believes to be an explosive or such ingredient or substance.

Any occupier of a store or registered premises or a small firework factory who refuses to comply with any such requisition of an officer of the local authority, or to give him such assistance as he may require for the purpose of this section, or who wilfully obstructs the local authority, or any officer of the local authority, in the execution of the Act, shall be liable to a penalty of £20 (s. 69).

Local Authority may provide Carriages and Magazines.

Every harbour authority and canal company shall, in addition to any other powers they may have for the like purpose, have power to provide carriages, ships, and boats for the conveyance, loading, or unloading of an explosive within the jurisdiction of such authority or company, and may charge a reasonable sum fixed by a bye-law under the Act for the use of such carriage, ship, or boat (s. 71).

General Power of Search.

Where any of the following officers—namely, any Government inspector, or any constable or any officer of the local authority, if such constable or officer is specially authorised either (*a*) by a warrant of a justice (which warrant such justice may grant upon reasonable ground being assigned on oath), or (*b*) (where it appears to a superintendent or other officer of police of equal or superior rank, or to a Government inspector, that the case is one of emergency and that the delay in obtaining a warrant would be likely to endanger life), by a written order from such superintendent, officer, or inspector—has reasonable cause to believe that any offence has been or is being committed with respect to an explosive in any place (whether a building or not, or a carriage, boat, or ship), or that any explosive is in any such place in contravention of the Act, or that the provisions of the Act are not duly observed in any such place, such officer may, on producing, if demanded, in the case of a Government inspector a copy of his appointment, and in the case of any other officer his authority, enter at any time, and if needs be by force, and as well on Sunday as on other days, the said place, and every part thereof, and examine the same, and search for explosives therein, and take samples of any explosive and ingredient of an explosive therein, and any substance reasonably supposed to be an explosive, or such ingredient which may be found therein.

Any person who, by himself or by others, fails to admit into any place occupied by or under the control of such person any officer demanding to enter in pursuance of this section, or in any way obstructs such officer in the execution of his duty under this section, shall be liable to a penalty of £50, and shall also be liable to forfeit all explosives, and ingredients thereof, which are at the time of the offence in his possession or under his control at the said place.

Where a constable or officer of the local authority specially authorised by written authority other than a warrant of a Justice of the Peace, enters and searches as above provided, a special report in writing of every act done by such constable or officer in pursuance of that authority, and of the grounds on which it is done, shall be forthwith sent by the person by whom or under whose authority it was done to the Secretary of State (s. 73).

Where any of the following officers—namely, any Government inspector, or any constable, or any officer of the local authority—has reasonable cause to believe that any explosive or ingredient of an explosive or substance found by him is liable to be forfeited under the Act, he may seize and detain the same until some Court of Summary Jurisdiction has determined whether the same is or is not so liable to be forfeited, and with respect thereto the following provisions shall have effect:

(1.) The officer seizing may either require the occupier of the place in which it was seized (whether a building or not, or a carriage, boat, or ship) to detain the same in such place or in any place under the control of such occupier, or may remove it in such manner and to such place as will in his opinion least endanger the public safety, and there detain it, and may, where the matter appears to him to be urgent and fraught with serious public danger, and he is a Government Inspector, or is authorised by an order from a Government Inspector or a Justice of the Peace, or from a superintendent or other officer of police of equal or superior rank, cause the same to be destroyed or otherwise rendered harmless; but before destroying or rendering harmless the same he shall take and keep a sample thereof, and shall, if required, give a portion of the sample to the person owning the explosive, or having the same under his control at the time of the seizure; and any such occupier who, by himself or by others, fails to keep the same when he is required in pursuance of this section to detain it, and any such occupier or other person who, except with the authority of the officer seizing the same, or of a Government Inspector, or in case of emergency for the purpose of preventing explosion or fire, removes, alters, or in any way tampers or deals with the same while so detained, shall be liable to a penalty not exceeding £50, and shall also be liable to forfeit all explosives, and ingredients thereof, which are at the time of the offence in his possession or under his control at the said place;

(2.) The proceedings before a Court of Summary Jurisdiction for determining whether the same is or is not liable to forfeiture shall be commenced as soon as practicable after the seizure; and

(3.) The receptacles containing the same may be seized, detained, and removed in like manner as the contents thereof; and

(4.) The officer seizing the same may use for the purposes of the removal and detention thereof any ship, boat, or carriage in which the same was seized, and any tug, tender, engine, tackle, beasts, and accoutrements belonging to or drawing or provided for drawing such ship, boat, or carriage, and shall pay to the owner a reasonable compensation for such use, to be determined, in case of dispute, by a Court of Summary Jurisdiction, and to be recovered in like manner as penalties under the Act; and

(5.) The same shall, so far as practicable, be kept and conveyed in accordance with the Act, and with all due precaution to prevent accident, but the person seizing, removing, detaining, keeping, or conveying the same shall not be liable to any penalty, punishment, or forfeiture, or to any damages, for keeping or conveying the same, so that he use all such due precautions as aforesaid; and

(6.) The officer seizing the same, or dealing with the same in pursuance of this section, shall not be liable to damages or otherwise in respect of such seizure or dealing, or any act incidental to or consequential thereon, unless it is proved that he made such seizure without reasonable cause, or that he caused damage to the article seized by some wilful neglect or default (s. 74).

Any of the following officers—namely, any Government Inspector under the Act, any chief officer of police, and any superior officer appointed for the purposes of this Act, where the justices in petty sessions are the local authority, by the court of quarter sessions to which such justices belong, and in the case of any other local authority by the local authority itself—may, for the purpose of ascertaining whether the provisions of the Act with respect to the conveyance, loading, unloading, and importation of an explosive are complied with, enter, inspect and examine at any time, and as well on Sundays as on other days, the wharf, carriage, ship, or boat of any carrier or other person who conveys goods for hire, or of the occupier of any factory, magazine, or store, or of the importer of any explosive, on or in which wharf, carriage, ship, or boat he has reasonable cause to suppose an explosive to be for the purpose of or in course of conveyance, but so as not to unnecessarily obstruct the work or business of any such carrier, person, occupier, or importer.

Any such officer, if he find any offence being committed under the Act in any such wharf, carriage, ship, or boat, or on any public wharf, may seize and detain or remove the said carriage, ship, or boat, or the explosive, in such manner and with such precautions as appear to him to be necessary to remove any danger to the public, and may seize and detain the said explosive, as if it were liable to forfeiture.

Any officer above mentioned in this section, and any officer of police, or officer of the local authority who has reasonable cause to suppose that any offence against the Act is being committed in respect of any carriage (not being on a railway) or any boat conveying, loading, or unloading any explosive, and that the case is one of emergency, and that the delay in obtaining a warrant will be likely to endanger life, may stop, and enter, inspect, and examine such carriage or boat, and by detention or removal thereof or otherwise take such precautions as may be reasonably necessary for removing such danger, in like manner as if such explosive were liable to forfeiture.

Every officer shall for the purpose of this section have the same powers and be in the same position as if he were authorised by a search warrant granted under the Act, and any person failing to admit or obstructing such officer shall be liable to the same penalty (s. 75).

When a Government Inspector, constable, or officer of the local authority takes samples of any explosive, or ingredient, or substance, he shall pay for or tender payment for the same to such amount as he considers to be the market value thereof, and the occupier of the place in which, or the owner of the bulk from which the sample was taken, may recover from the officer taking the sample, as a debt in the county court, any excess of the real value over the amount so paid or tendered, and any amount so tendered (s. 76).

PART IV.—SUPPLEMENTAL PROVISIONS.

Trespassers and Offenders.

Any person who enters without permission or otherwise trespasses upon any factory, magazine, or store, or the land immediately adjoining thereto which is occupied by the occupier of such factory, magazine, or store, or on any wharf for which bye-laws are made by the occupier thereof under the Act, shall for every such offence, if not otherwise punishable, be liable to a penalty not exceeding £5, and may be forthwith removed from such factory, magazine, store, land, or wharf, by any constable, or by the occupier of such factory, magazine, store, or wharf, or any agent or servant of or other person authorised by such occupier.

Any person other than the occupier of or person employed in or about any factory, magazine, or store who is found committing any act which tends to cause explosion or fire in or about such factory, magazine, or store, shall be liable to a penalty not exceeding £50.

The occupier of any such factory, magazine, store, or wharf shall post up in some conspicuous place or places a notice or notices warning all persons of their liability to penalties under this section; but the absence of any such notice or notices shall not exempt a person from a penalty under this section (s. 77).

Any person who is found committing any act for which he is liable to a penalty under the Act, and which tends to cause explosion or fire in or about any factory, magazine, store, railway, canal, harbour, or wharf, or any carriage, ship, or boat, may be apprehended without a warrant by a constable, or an officer of the local authority, or by the occupier of or the agent or servant of or other person authorised by the occupier of such factory, magazine, store, or wharf, or by any agent or servant of or other person authorised by the railway or canal company or harbour authority, and be removed from the place at which he is arrested, and conveyed as soon as conveniently may be before a court of summary jurisdiction.

Where any person is guilty of any offence which under the Act is punishable by a pecuniary penalty only, and which, in the opinion of the court that tries the case, was reasonably calculated to endanger public safety or to cause serious personal injury, or to cause a dangerous accident, and was committed wilfully by the person accused, such person shall be liable to six months' imprisonment, with or without hard labour (s. 78).

Every person who forges or counterfeits any license, certificate, document, or plan granted or required in pursuance or for the purposes of the Act, or gives or signs any such document or plan which is to his knowledge false in any material particular, or wilfully makes use of any such forged, counterfeit, or false license, certificate, document, or plan, shall be liable to imprisonment, with or without hard labour, for a term not exceeding two years (s. 81).

Every person who, without due authority, pulls down, injures, or defaces any notice, copy of rules, or document, when affixed in pursuance of this Act, or of the special rules, shall be liable to a penalty not exceeding two pounds (s. 82).

Legal Proceedings.

Where any offence under the Act for which the occupier of any factory, magazine, store, or registered premises is liable to a penalty or forfeiture has in fact been committed by some other person, such other person shall be liable to a penalty not exceeding twenty pounds, and the occupier shall be exempt from any penalty and forfeiture upon proving that he had used due diligence to enforce the observance of the Act, and had taken all practicable means in his power to prosecute the actual offender to conviction; and where a Government Inspector, or an officer of the local authority, or the local authority, is satisfied that such occupier would, under the foregoing provisions, be exempt, and the occupier gives all facilities for proceeding against and convicting the actual offender, the inspector, officer, or local authority shall proceed against that person in the first instance, without first proceeding against the occupier.

Where any offence under the Act for which any warehouseman, carrier, occupier of a wharf or dock, or owner or master of any ship, boat, or carriage, is liable to a penalty or forfeiture, has in fact been committed by some other person, this section is to apply in like manner as in the case of an occupier (s. 87).

Where a carrier or owner or master of a ship or boat is prevented from complying with the Act by the wilful act, neglect, or default of the consignor or consignee of the explosive, or other person, or by the improper refusal of the consignee or other person to accept delivery of the explosive, such consignor, consignee, or other person who is guilty of such wilful act, neglect, default, or refusal, shall be liable to the same penalty to which the carrier, owner, or master is liable for a breach of the Act, and his conviction shall exempt the carrier, owner, or master from any penalty or forfeiture under the Act (s. 88).

Where a court before whom a person is convicted of an offence against the Act has power to forfeit any explosive, the court may, if they think it just and expedient, in lieu of forfeiting such explosive, impose upon such person, in addition to any other penalty or punishment, a penalty not exceeding such sum as appears to the court to be the value of the explosive so liable to be forfeited.

Where any explosive, or ingredient of an explosive, is alleged to be liable under the Act to be forfeited, any indictment, information, or complaint may be laid against the owner of such explosive or ingredient, for the purpose only of enforcing such forfeiture; and where the owner is unknown, or cannot be found, a court may cause a notice to be advertised, stating that unless cause is shown to the contrary at the time and place named in the notice, such explosive will be forfeited, and at such time and place the court, after hearing the owner or any person on his behalf, may order all or any part of such explosive or ingredient to be forfeited (s. 89).

Every offence under the Act may be prosecuted, and every penalty under the Act recovered, and all explosives and ingredients liable to forfeiture under the Act may be forfeited, either on indictment or before a court of summary jurisdiction, provided that the penalty shall not exceed £100, exclusive of costs, and of any forfeiture or penalty in lieu of forfeiture, and the term of imprisonment shall not exceed one month. All costs and penalties may be recovered before a court of summary jurisdiction.

A court of summary jurisdiction may by order prohibit a person from doing any act, for doing which such person has twice been convicted under the Act, and may order any person disobeying such summary order to be imprisoned for any period not exceeding six months (s. 91).

The court of summary jurisdiction, when hearing and determining an information or complaint, in respect of any offence under the Act, shall be constituted either of two or more justices of the peace in petty sessions, or of a magistrate empowered by law to do alone any act authorised to be done by more than one justice of the peace.

Nothing in the Act shall render liable to any penalty or forfeiture the owner or master of any ship or boat, or any carrier or warehouseman, or the person having charge of any carriage, for any act done in breach of the Act, if he prove that by reason of stress of weather, inevitable accident, or other emergency, the doing of such act was, under the circumstances, necessary and proper (s. 100).

Definition and Classification of Explosives.

Her Majesty is empowered, by Order in Council, to declare that any substance which appears to Her Majesty to be specially dangerous to life or property by reason either of its explosive properties, or of any process in the manufacture thereof being liable to explosion, shall be deemed to be an explosive within the meaning of the Act; and Her Majesty is also empowered from time to time, by Order in Council, to define, for the purposes of the Act, the composition, quality, and character of any explosive, and to classify explosives (ss. 104, 106).

Any person who carries on any of the following processes—namely, the process of dividing into its component parts or otherwise breaking up or unmaking any explosive, or making fit for use any damaged explosive, or the process of remaking, altering, or repairing any explosive, shall be subject to the provisions of this Act as if he manufactured an explosive, and the expression "manufacture" in the Act is to be construed accordingly (s. 105).

Table of Fees.

The following are to be the maximum fees for licenses and certificates granted by the Secretary of State (s. 26).

Factory license, original - - -	Ten pounds.
,, ,, amending - - -	Five pounds.
,, ,, renewal when lost -	Five shillings.
Magazine license, original - - -	Ten pounds.
,, ,, amending - -	Five pounds.
,, ,, renewal when lost -	Five shillings.
Importation license, first grant - -	One pound.
,, ,, renewal - -	Ten shillings.
Continuing certificate - - -	Forty shillings.

TABLE OF EXPLOSIVES authorised to be manufactured, with the number of Factories in which each could be made at the end of each year since the passing of the Act.

Class.	Division.	Name of Explosive.	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893
1	..	Gunpowder	29	29	28	28	28	28	28	28	28	28	28	29	28	29	29	29	30	29
2	..	Espir's Explosive Powder	..	..	1	1	1	1	1	1	1	1	..	..	..	..	..	..	..	..
		Pudrolithe	1	1	1	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..
		Safety Blasting Powder	..	..	..	..	..	..	1	1	1	1	1	1	1	1	1	1	1	1
3	1	Ardeer Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Amberite, No. 1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Ballistite	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	2	2
		Blasting Gelatine, Nos. 1 and 2	..	..	..	..	1	1	1	1	1	1	1	1	1	1	2	2	3	4
		Camphorated Gelatine	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1
		Carbo-Dynamite	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Carbonite	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Dynamite, Nos. 1 and 2	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	4	4	5
		E.C. Dynamite	..	..	..	..	..	..	..	1	1	1	1	..	..	..	..	..	..	..
		Gelatine Dynamite, Nos. 1 and 2	..	..	..	..	..	..	..	1	1	1	1	1	1	1	2	2	3	4
		Lithofracteur	..	..	..	..	..	..	1	1	1	1	1	1	1	1	1	1	1	1
		Oarite	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Primers for Gelatine	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	2
3	2	Amberite, No. 2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Ammonite	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		Cannonite, Nos. 1 and 2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Collodion Cotton	..	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Compressed Securite	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Cooppal's Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		Cotton Gunpowder	1	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Denaby Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Diflamyr	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		E.C. Sporting Powder	..	..	..	..	..	..	1	1	2	2	2	2	2	3	3	3	3	3
		E.C. Sporting Powder, J.B. Patent	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..
		E.C. Powder Co.'s Rifle Powder	..	..	..	..	..	..	1	1	2	2	2	2	2	3	..	..	..	..
		E.C. Powder Co.'s Rifle Powder, J.B. Patent	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1

TABLE OF EXPLOSIVES—*Continued.*

Class.	Division.	Name of Explosive.	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893
		Flameless Securite	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
		Gathurst Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Guncotton	4	5	5	5	5	4	5	5	6	6	6	6	6	7	7	8	8	8
		Nitrated Guncotton	2	3	3	3	3	2	3	3	4	4	4	4	4	5	5	5	5	5
		Picric Acid	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		*Potentite	..	..	..	..	1	1	1	1	1	1	1	1	2	2	2	2	2	2
		Rifleite	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Rifle Guncotton	2	3	3	3	3	2	2	2	3	3	3	3	3	4	4	4	4	4
		Roburite, Nos. 1 and 2	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1
		Sawdust and Guncotton Powder	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Sawdust Gunpowder	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Schultze Gunpowder	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
		Schultze Blasting Powder	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
		Securite	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		Smokeless Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		Smokeless Blasting Powder	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
		Tonite or Cotton Powder, Nos. 1 and 2	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	3	3
		Tonite or Cotton Powder, No. 3	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1
		Wood Gunpowder	..	1	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..
		Xylobrome	..	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	1	Fulminate of Mercury	2	2	2	2	3	3	4	5	5	5	5	5	5	5	5	6	6	6
6	1	Percussion Caps	6	6	6	5	5	5	5	7	7	8	8	8	8	9	10	10	9	9
		Railway Fog Signals	5	5	5	6	8	8	8	9	10	10	12	12	12	14	14	14	14	14
		Safety Cartridges	9	8	8	8	8	8	9	12	12	13	13	13	15	19	21	22	22	22
		Safety Firing Tubes, No. 1	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1	1
		Safety Fuse	5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
		Tube Safety Fuse	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1	1
6	2	†Bickford's Patent Volley Firers	..	..	..	..	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		‡Cartridges for Small Arms	4	4	4	4	4	4	6	8	8	8	8	8	8	10	13	13	13	13
		§Cartridges for Cannon, Blasting, &c.	3	7	7	9	13	13	14	15	15	16	18	19	21	25	25	25	26	26

* First known as Liverpool Cotton Powder or Potentite. † First known as Patent Igniters.

‡ Not including "rooms" in connection with magazine stores and registered premises under Section 46.

§ Not including the factories in which, under Section 44, they may be made without a license, or the "workshops" used in connection with magazines and stores under Section 47.

TABLE OF EXPLOSIVES—*Continued.*

Class.	Division.	Name of Explosive.	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893
6	3	Electric Fuses	..	1	2	2	3	3	4	4	4	6	6	6	6	6	8	8	9	10
		Electric Primers	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Electric Tubes	..	..	..	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3
		Fuses for Shells	1	2	2	2	2	2	2	2	2	3	3	3	3	5	5	6	6	7
		German Spills	..	..	..	1	1	1	2	2	2	2	2	2	2	2	3	3	3	2
		Guncotton Fuses	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Gunpowder Fuses	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Hunter's Patent Miners' Fuzes	..	..	..	..	..	..	1	1	1	1	..	..	..	..	..	..	..	..
		Instantaneous Fuse	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Metallic Blasting Fuze	..	..	..	1	1	1	..	1	1	1	1	1	1	1	1	1	1	1
		Miners' Squibs	..	..	..	..	..	..	1	1	1	1	1	1	1	1	1	1	2	2
		Shells	..	..	..	..	..	..	..	..	..	1	2	2	2	2	2	4	4	4
		Tubes for Firing Explosives	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
		War Rockets	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
		*Cartridges for Small Arms	3	3	3	3	3	3	3	5	5	5	5	5	5	5	6	8	8	8
		Colliery Safety Lighters	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1	1
		Detonators	2	4	4	4	3	3	4	4	4	4	4	4	4	5	6	6	7	6
		Double Detonator Fuses	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Electric Detonators	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
		Electric Detonator Fuses	..	..	2	2	2	2	3	3	3	5	5	5	5	5	7	7	8	9
		Fuses for Shells	1	2	2	2	2	2	2	2	2	3	3	3	5	5	5	6	6	6
		†Metallic Cartridges containing Gunpowder	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1	1
		‡Quick Firing Ammunition	..	..	..	..	..	..	..	..	..	..	..	2	6	8	8	8	8	8
		Safety Firing Tubes, No. 2	..	..	..	..	..	..	..	..	..	..	1	1	1	1	1	1	1	1
		Socket Light	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
		Sound Signal Rockets	..	..	..	..	..	..	1	1	1	1	1	1	1	1	1	1	..	..
		Sound Socket Signals	..	..	..	..	1	1	1	1	1	1	1	1	1	..	..	..	..	..
		Tubes for Firing Explosives	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
7	..	Fireworks	12	18	20	24	25	24	25	24	24	25	25	23	24	24	24	25	26	24
		Toy Fireworks	..	..	9	14	15	14	13	13	13	13	16	13	12	12	12	10	11	11

* Not including "rooms" used in connection with magazines, stores, and registered premises under Section 46.
† For use on an adjoining range only.
‡ For Her Majesty's Land and Sea Forces; extended in 1892 to private sale and direct exportation in certain cases.

PORTS for which IMPORTATION LICENSES FOR EXPLOSIVES are authorised to be granted.

Name of Port.	County.	Harbour Authority.	Bye-Laws approved. Date.	Whether a Port approved by Customs.
Aberdovey	Merioneth	A. J. S. Corbet, Esq.	4/12/77	Approved— 8th July 1881 $\frac{99{,}536}{9}$
Bristol	Gloucester	The Corporation of Bristol	1/7/76	Do.
Barrow	Lancashire	The Furness Railway Co.	24/9/78	Do.
Burntisland	Fife	The Corporation	11/10/78	Do.
Clyde (River)	Lanark	The Trustees of the Clyde Navigation	25/6/78	Do.
Clyde (Lower Estuary)	Lanark	The Board of Trade	14/2/77	Do.
Clyde (Upper Estuary)	*See* Clyde.			
Conway (Harbour)	Carnarvon	The Corporation	31/8/77	Do.
Falmouth	Cornwall	The Falmouth Harbour Commissioners	4/12/76	Do.
Glasgow	Lanark	The Clyde Navigation Trustees	25/6/78	Do.
Goole	York	The Trustees of the Aire and Calder Navigation, Goole	7/11/76	3/12/84 $\frac{99{,}536}{34}$
Greenock	Renfrew	*See* Lower Clyde.		
Grangemouth	Stirling	Forth and Clyde Navigation	12/5/77	8th July 1881 $\frac{99{,}536}{9}$
Hull	York	The Corporation of Hull	21/3/77	Do.

IMPORTATION LICENSES FOR EXPLOSIVES—*Continued.*

Name of Port.	County.	Harbour Authority.	Bye-Laws approved. Date.	Whether a Port approved by Customs.
Humber	York	The Humber Conservancy	14/4/77	Approved— 8th July 1881 $\frac{99,536}{9}$
Irvine	Ayr	The Irvine Harbour Trustees	14/4/77	Do.
King's Lynn	Norfolk	The Corporation	27/10/76	Do.
London	Middlesex	The Conservators of the River Thames	26/1/76 19/11/78 20/10/80 7/11/81	Do.
Liverpool	Lancashire	The Mersey Docks and Harbour Boards	12/7/77	Do.
Leith	Edinburgh	The Commissioners for the Harbour and Docks of Leith	22/9/76 12/2/77	Do.
Mersey	Lancashire	The Mersey Docks and Harbour Board	12/2/77	Do.
Penarth	Glamorgan	The Lessees, Taff Vale Railway Co., Cardiff	6/11/82	19th March 1883 4,714
Newport	Monmouth	The Newport Harbour Commissioners	6/11/82	Do.
Portsmouth	Hants	The Lords Commissioners of the Admiralty	7/6/78	8th July 1881 $\frac{99,536}{9}$
Pembrey	Carmarthen	The Corporation	6/4/83	$\frac{52819H}{5}$

IMPORTATION LICENSES FOR EXPLOSIVES—*Continued.*

Name of Port.	County.	Harbour Authority.	Bye-Laws approved. Date.	Whether a Port approved by Customs.
Penzance	Cornwall	The Mayor, Aldermen, and Burgesses	20/2/79	Approved— 14/11/81 54118v/6
Penryn	Cornwall	The Corporation	9/10/79	23/11/81 54118v/8
Plymouth	Devon	The Lords Commissioners of the Admiralty	1/11/79	23/11/81 54118v/10
Portmadoc	Carnarvon	Edward Breeze, Esq.	30/4/77	8th July 1881 99,536/9
Southampton	Hants	The Southampton Pier and Harbour Board	27/7/76	Do.
Thames		The Conservators of the River Thames	26/1/76 22/11/76 19/11/78 20/10/80 7/11/81	Do.
Tyne	Northumberland	The Tyne Improvement Commissioners	9/8/77	Do.
Whitehaven	Cumberland	The Trustees of the Town, Port, and Harbour of Whitehaven	28/8/79	Do.

NON-PROHIBITED PORTS in IRELAND under the PEACE PRESERVATION ACT, 1881, &c., *i.e.*, Ports into which Explosives not requiring a License under the Explosives Act, 1875, may be brought.

Name of Port.	County.	Harbour Authority.	Bye-Laws approved. Date.	Act under which Authorised.
Belfast	Antrim	The Harbour Commissioners, Belfast	14/12/76	Authorised under Peace Preservation Act, Order in Council, 24th Feb. 1893. "The Peace Preservation (Ireland) Continuance Act, 1886," "The Criminal Law and Procedure (Ireland) Act, 1887," and "The Expiring Laws Continuance Act, 1892."
Carrickfergus	Antrim	The Carrickfergus Harbour Commissioners	3/5/77	
Cork	Cork	The Cork Harbour Commissioners	14/7/77	
Drogheda	Louth	The Harbour Commissioners, Drogheda	8/5/77	
Dundalk	Louth	The Harbour Commissioners, Dundalk	1/11/78	
Dublin	Dublin	The Dublin Port and Docks Board	18/1/77	
Galway	Galway	The Harbour Commissioners, Galway	10/12/77	
Glenarm	Antrim	The Earl of Antrim, Glenarm Castle, Co. Antrim	Nil.	
Greenore	Louth	The Dundalk and Greenore Railway Co., Greenore	25/3/76*	
Larne	Antrim	James Chaine, Esq., Ballycraigey, Co. Leitrim	—	
Limerick	Limerick	The Harbour Commissioners, Limerick	5/8/78	
Londonderry	Londonderry	The Harbour Commissioners, Londonderry	6/11/78	
Newry	Down	The Newry Navigation Co.	8/9/76	
Sligo	Sligo	The Harbour Commissioners, Sligo	23/10/76	
Waterford	Waterford	The Harbour Commissioners, Waterford	8/9/82	
Westport (Quay)	Mayo	The Westport Harbour Commissioners	5/5/93	
Wexford	Wexford	The Harbour Commissioners, Wexford	10/1/77	

* Greenore Harbour. Prohibitory Bye-laws made.

PART II.

NOTES OF INSTRUCTIVE ACCIDENTS WITH VARIOUS MATERIALS, ILLUSTRATING THEIR NATURE.

PART II.

INSTRUCTIVE ACCIDENTS.

AMMONIUM HYDRATE (AMMONIA).

On a hot summer's day a laboratory assistant was in the act of opening a Winchester quart bottle of strong ammonia solution for the writer, and no sooner had he relieved the stopper from the linseed meal surrounding it, than half the ammonia shot out of the bottle with tremendous force, leaving a residue of the liquid in the bottle in a state of violent ebullition for some time. The unfortunate young man had a narrow escape of his life. A quantity of the liquid dashed into his face, and some of it must have reached his stomach, because his abdomen swelled to an immense size; but a timely administration of dilute hydrochloric acid quickly brought it down to its normal condition, otherwise the consequences must have been fatal. His face and eyes were badly burnt, and the skin of his tongue and lips so cauterised that the whole peeled off. His heart has since been chronically affected by the strain.

Bottles containing strong solution of ammonia should be kept in a cool place, and the stoppers should be taken out at arm's-length, especially in the summer months.

ANHYDROUS AMMONIA.

An explosion of a cylinder of this compressed gas took place on board a steamer in the tropics in October 1891. It appeared that the poop-hold contained 23 or 24 wooden cases containing wrought-iron cylinders of ¼-inch iron, 7 feet long and 8½ inches outside diameter. A tube, which was afterwards found to contain a flaw, burst, the escaping ammonia gas killing one man, and considerable damage was done to the ship.

BENZOL (MINERAL SPIRIT).

A truck containing 8 puncheons of mineral spirit of about 100 gallons each was being shunted at the Holloway Station of the Great Northern Railway when it came into collision with an engine, causing the barrels containing the benzol to leak. The exuding volatile liquid quickly caught fire, and enveloped the driver and fireman in flames, both being burnt to death. The flash point of the spirit was 10° F., and it was known as 90 per cent. benzol.

Highly inflammable liquids of this nature should not be conveyed in barrels, but in properly secured iron drums.

BLASTING GELATINE.

Several cases of explosions with this stuff have recently been reported upon by H.M. Inspectors of Explosives, which tend to show that blasting gelatine is liable to spontaneous decomposition, especially if kept for some time in hot countries.

A terrible explosion of a magazine containing 17,450 lbs. of blasting gelatine and 5,450 lbs. of dynamite took place at Bombay in 1891. The magazine in question was substantially built, with walls of stone laid in mortar, with an arched roof. The report by the committee appointed to inquire into the affair stated that "early on the morning of the 28th December 1891 the watchmen observed smoke issuing from the ventilators of the magazine, and as the smoke increased the men ran away, and shortly after this the explosion occurred. One of the watchmen ran to the nearest police station, a distance of about 1,000 yards, and had just arrived at the station as the explosion took place; so it may be reasonably assumed that between the time when smoke was first observed and the explosion could not have been less than 10 to 15 minutes, but there is no evidence as to how long a time the burning had been in progress inside the building before the smoke was discovered.

"There is no reason to suppose that the explosion was due to other than accidental causes, and the opinion of the committee is, that some of the explosives (probably some of the blasting gelatine) had become unstable, owing to decomposition, and that there was spontaneous ignition of some case or cases; that the effect of the burning in an enclosed building was to heat some portion of the explosives to a temperature approaching their exploding point, and that eventually the fire inside the magazine ended as it was bound to under the circumstances."

COAL DUST.

Coal dust, until quite recently, was not considered to be a primary cause of the disastrous colliery explosions we too frequently hear of. But it has now been proved beyond doubt that a mixture of air and coal dust, under certain conditions, is highly explosive, and that it is not necessary that there should always be fire-damp or marsh gas present in a mine as the cause of an explosion.

Respecting the explosions produced by air and coal dust, the Second Report of the Royal Commission on Explosions in Mines, published in 1894, says:—

"On a general review of the evidence on this point, we have no hesitation in expressing our opinion that a blown out shot may, under certain conditions, set up a most dangerous explosion in a mine, even where fire-damp is not present at all or only in infinitesimal quantities, and while we are prepared to admit that the danger of a coal dust explosion varies greatly according to the composition of the dust, we are unable to say that any mine is absolutely safe in this respect, or that its owners can properly be absolved from taking reasonable precautions against a possible explosion from this cause. But even if we had been able to come to a different conclusion, and to agree with the minority of the witnesses examined, who think that coal dust alone cannot originate an explosion, we should still have to call attention to the serious danger which results from the action of coal dust in carrying on and extending an explosion which may originally have been set up by the ignition of fire-damp."

From some interesting experiments conducted by Messrs Hall & Galloway, it would seem that the products of combustion of such explosives as gunpowder and blasting gelatine, used in mines, contain a large quantity of combustible gases, such as carbon monoxide, hydrogen, and marsh gas; and the production of these gases in a dusty mine is highly conducive to an explosion. The products of combustion of the class of explosives such as roburite and ammonite contain no gases capable of further combustion, and it would appear that it is this class of explosives which should always be used in mining operations.

There can be no doubt that the explosion which took place in 1893 at the Camerton Collieries, Somersetshire, was caused by the ignition of a mixture of the products of combustion of a gunpowder shot, air, and coal dust, since no trace of fire-damp could be detected in the mine before or after the explosion.

Now that it has been substantiated that colliery explosions may be brought about by the ignition of coal dust and air in the presence of small quantities of marsh gas, or of the combustible gases resulting from blasting operations with such explosives as gunpowder, and that by the use of roburite, ammonite, and such-like explosives for blasting there are no combustible gaseous products given off, so that safeness is secured on that score, it must not be forgotten that the products of combustion given off from ill-trimmed safety lamps, or from unsuitable oils burnt in them, will contain notable quantities of combustible vapours. There can be no doubt that the regulation of the quality of oil supplied for burning in miners' safety lamps is also deserving of attention (*see also* p. 259).

A terrible explosion, principally due to coal dust, took place some time ago on board the "Eugene Pereire" in Marseilles Harbour. It appears there was a heavy slip of coal in an open bunker which raised a dense cloud of dust, and on this coming in contact with a lamp in the stoke-hole, there was an explosion of great violence, causing the death of one man and severely injuring four others.

A singular case of fire, said to be due to coal dust and petroleum vapour, occurred on board the "Ellida" while being loaded with coal at Cardiff in September 1887. At about midnight the whole of the vessel was found to be in flames. It appeared that the vessel had been in the petroleum trade for some years between England and America.

The owners of the vessel instituted an action against the shippers to recover damages, which they said were due to the carelessness of the shippers' men in the use of lights. It was proved that there had been a leakage of petroleum from a previous cargo, and the defendants argued that the fire was caused through the ignition of coal dust and petroleum vapour. This was the view taken by the judge (Mr Justice Wills), and he gave judgment accordingly. Upon the plaintiffs taking the case to Court of Appeal, the judgment was confirmed.

COAL GAS EXPLOSIONS.

During the repairing of gas mains in Bermondsey, at 4.45 in the afternoon, a serious explosion took place consequent upon the ignition of escaping gas in the surrounding air, resulting in serious injury to two passers-by, and considerable damage to the surrounding property.

The steamer "Suppwich," with a cargo of 2,000 tons of coal, called off Penzance, and reported a serious explosion on board, which had resulted in the mate being seriously burnt, and three other men injured. It appears that a seaman went into the hold with a lighted lamp, and the explosion immediately followed.

All coal give off more or less inflammable gases—principally marsh gas—at the ordinary temperature, and naked lights should not be taken into any confined place where coal or other material is stored, liable to give off inflammable gases. The report of a committee appointed by the Admiralty states that "the gas which may be evolved from coal, under the varying conditions in which it is stored in ships' holds, will form explosive mixtures with proportions of air ranging from 6 to 16 times the volume of gas, and that the most violent explosive mixtures are produced when the proportions of gas represent 1 volume in 9 to 12 volumes of a mixture."

Serious explosions of coal gas, resulting from leaky mains in contact with electric wires, are becoming of frequent occurrence, in the Metropolis and other large towns; and unless some different system is devised for keeping these rival vehicles of light apart, we may expect to hear of many more such accidents, especially in view of the fact that electric lighting is developing at a great rate, and wires are being laid in all directions.

The damage to life and property that might result from these explosions in our public thoroughfares, can be best imagined from the description of a few such catastrophes:—

An explosion occurred one afternoon on Southwark Bridge, when as many as five holes were blown up in the roadway over the electric mains, resulting from a leakage of gas from a main. Two women and a man were so severely injured that they had to be taken to the hospital, and several workmen engaged on the bridge had narrow escapes of their lives. Serious damage was done to the bridge.

Shortly after midnight, upon a Saturday, some persons passing between Gower Street Station and Endsleigh Gardens, in the Euston Road, heard rumbling sounds from under the pavement, and it was supposed "something had occurred" on the Metropolitan Underground Railway, which runs beneath the roadway. The rumbling sounds were followed by a loud explosion. The pavement-stones, from the corner of Endsleigh Gardens for some 50 to 60 yards towards Gower Street Station, were thrown up, and persons passing along had to run, to escape danger, into the roadway. It was noticed that the explosion took place at the chamber-box of the electric light connected with the St Pancras Vestry's system, and placed near the corner of Endsleigh Gardens, for the lid of the box was blown completely out into the roadway with great force, while flashes of light, as of gas escaping, came from the casement. Examination showed that the accident was entirely due to an escape of gas from the mains, exploded by electric sparks from the wires hard by. Two persons were injured.

Major Cardew, who held an inquiry on behalf of the Board of Trade into the circumstances attending the explosion, made the following report :—

> "After careful consideration of the evidence, and of my own investigations, I am of opinion that the explosions were caused by the firing of a mixture of coal gas and air by an electric spark. I account for the presence of the coal-gas by leakage from the mains of the Gas Light and Coke Company at one or more points in the vicinity of the electric light conduits. The means provided by the Vestry for the immediate escape of any gas from their conduits are, in my opinion, totally inadequate. The Vestry of St Pancras should lose no time in removing the existing causes of danger which I have indicated, viz., the possibility of an accumulation of coal gas in their conduits, and that of the occurrence of an electric spark at their bare conductor mains. This system of mains and conduits was selected mainly for economical reasons, but these economical advantages must not be reaped at the expense of the safety of the public using the streets. The Vestry were advised a year ago to carry out a system of efficient ventilation. It was further recommended that where possible two small chambers should be substituted for the large ones at present in use as street boxes, and that the low insulation of the negative main should be remedied. Sufficient attention has not, I consider, been paid by the Vestry to these recommendations. I am of opinion that the Vestry should immediately provide a thorough system of ventilation, or means for the immediate escape of gas from their conduits and street boxes, should reduce the empty space available for accumulation of gas in their street boxes as far as possible, and should carefully guard against the dangerous formation of an incrustation of salts on the insulators of the negative main by frequent inspection, and by protecting these insulators against drip from the condensation of moisture on the iron lids of the street boxes."

During a hurricane on 12th December 1883, at Clayton, near Bradford, a large gas-holder holding 250,000 cubic feet of gas was completely blown over. The escaped gas caught fire from the flame of a lamp hard by, which resulted in a huge flame that brilliantly illuminated the neighbourhood for miles around. Strange to say there was no explosion, owing to the fact that the gas became ignited before it had mixed with sufficient air necessary to produce an explosive compound ; otherwise, the consequence would have been serious. Ordinary coal gas requires to be diluted with 8 to 11 times its volume of air to produce an explosive mixture.

A terrific report of a gas explosion was heard in Ropemaker Street, London, soon after eight o'clock in the morning, the back part of the premises occupied as a boot and shoe factory being blown out. On the ground floor of the premises is the engine-house, with a gas-engine of 30 horse-power, and it appeared that the gas supply to the engine became overheated. In the explosion which followed, the engine was smashed to pieces, the engine-room was wrecked, and the windows blown out, together with blocks of lasts, stored on the floor. Some of these lasts, weighing 2 lb. each, were blown to a distance of 70 feet. One man was severely hurt, while two other men in the engine-room escaped with little injury. The damage to the building was so great that over 200 hands were temporarily thrown out of employment.

COLLODION.

A serious explosion took place in Paris some time ago, with this substance, on the premises of M. Chapron. It appears a carboy containing collodion (gun-cotton dissolved in alcohol and ether), fell in the workshop, and the ethereal vapours, mixed with air, came in contact with a stove, an explosion following, which resulted in the death of three persons, and severe injuries to two others, shattering the windows and setting the place on fire.

COLOURED FIREWORKS COMPOSITIONS.

A case of Bengal lights took fire spontaneously, whilst standing in a L. and N.-W. Railway truck. Fortunately the fire was promptly controlled, or the consequences would have been serious.

A gentleman travelling on the Manchester, Sheffield, and Lincolnshire Railway, placed a leather bag containing a bottle of a mixture for producing Bengal fire, on the middle seat of a first-class carriage. When the train was being pulled up an explosion occurred, which resulted in injury to the owner of the bag, and two other passengers. The mixture consisted of unwashed flowers of sulphur and chlorate of potash, and there can be no doubt that this was a clear case of "spontaneous" combustion.

The Home Office Authorities have frequently drawn attention to the risk attending the storage and transport of goods containing mixtures of this kind.

CORDITE.

The following striking observations appeared in the *Daily Telegraph* anent the blowing up, on the 24th January 1895, of the powder barge "Petrel," which contained a cargo of two and a half tons of cordite, and three boat loads of live shell:—

> "A prodigious calamity has been averted in the Thames—a calamity which might have cost scores of lives and many tens of thousands in property. There was a fire-ship afloat; a craft deadlier than was ever rigged and launched in the days of the Armada or the Dutch wars, and if she had exploded in Gravesend Reach instead of upon the lonely edge of the Bligh Sand—as was the case—our columns might be filled to-day with melancholy details of death and destruction. It was the powder-barge 'Petrel,' carrying guns and explosives for the Admiralty—such a craft as steamer-passengers often pass unwittingly upon the river, unless they understand what is the significance of the red flag hoisted at the mast-head.
>
> "The 'Petrel' was to carry a new twelve-inch quick-firing gun to Shoeburyness for trial, calling at Purfleet for two and a half tons of powder and three boat-loads of live-shell. With this perilous cargo she sailed from Purfleet with a hard wind from the north-west. In the Lower Hope the three men and a lad who were on board could not keep her off the sand. She dragged her anchor, and got hard and fast aground; whereupon, after the fashion of bargemen, the crew, who would be well accustomed to such harmless shipwrecks, 'went below, and after a smoke dropped to sleep.' Luckily one hand kept watch, and about midnight he saw smoke issuing from the forecastle. The fire-ship was on fire. So well did the crew comprehend what this might imply that, bitterly cold as the night was, two of them jumped overboard at once, and swam or waded to the shore; but, finding the lad was not with them, came bravely back for him, and took him off.

"The master, by name Lott, would not leave his vessel, and was last seen, with his clothes on fire, leaping from the bows, near to the moment when an explosion took place. First, shell after shell went off with the uproar of a bombardment; and finally the two and a half tons of cordite fired with a shock which thundered far and wide over the lonely marshes, blowing the barge to splinters, and sinking the brand-new gun in the ooze. The three survivors had to trudge, wet and half-clad, over the frozen marshes for eight miles, until they found shelter near Rochester.

"The dutiful skipper was the only loss, if we except the new twelve-inch gun and the barge itself. If, however, this had happened in Gravesend Reach instead of the Lower Hope; if the barge had gone ashore under Rosherville or the Terrace Pier, or fouled one of the big merchantmen in the fairway while on fire, we might have had such a disaster to record as would have been at least as destructive as the explosion on board a powder barge in the Regent's Park some twenty years ago, which wrecked an entire neighbourhood."

CHARCOAL.

Some "charcoal blacking," packed in bags, was consigned to the L. and N.-W. Railway Company, and stored in a warehouse. The bags had not been there long before a fire resulting from spontaneous combustion was discovered. On examination the substance was found to consist of finely ground charcoal, commonly known as moulders' black.

CHLORATE OF POTASH.

When a truck containing casks filled with this substance was being conveyed on the L. and N.-W. Railway, a fire broke out which destroyed the truck and its contents. The causes for the fire may be as follows:—That some of the chlorate escaped from the packages, and got mixed with organic matters in the truck, the friction produced in transit being sufficient to cause ignition. Or it may be that the chlorate was mixed with organic impurity, and the friction of the chlorate crystals produced sufficient heat for ignition. Or it may even be possible that the friction produced with the crystals upon the inside of the wooden casks, may have been sufficient to set up combustion.

While chlorate of potash in itself is not liable to spontaneously decompose, it contains such an abundance of available oxygen, that mere friction with combustible materials, under favourable circumstances, may produce a conflagration.

It should be conveyed in metallic packages, and care taken that there be no organic matter or other impurities mixed with the salt.

COMPRESSED GASES.

A boy named Fuller, aged fourteen, was commissioned to take two steel cylinders of compressed gas,—one containing oxygen and the other coal gas, to the Exchange Station, Bradford. While passing through the station subway, the oxygen cylinder fell from the lad's shoulder to the ground, and instantly exploded, scattering fragments of iron in all directions. The unfortunate boy was killed instantly by the flying metal, his head being shattered, and his body mutilated. The coal gas cylinder remained intact.

The pressure of the gas in the cylinders was 120 atmospheres, and each of them would weigh about 25 lbs. The explosion was undoubtedly due to the high tensile strength of the steel, which was found to be over 50 lbs. per square inch, thus making it brittle for the purpose. The steel used for these cylinders should not have a tensile strength exceeding 32 lbs. per square inch, and should be of the best quality with a percentage of carbon not above 0.25, and it should be thoroughly annealed after manufacture.

A Mr Bewley, shipbuilder, of Dublin, lost his life by an explosion of oxygen and hydrogen escaping from cylinders in a room where there was a lighted gas jet.

A serious explosion of a cylinder containing compressed hydrogen took place early in 1894, in First Avenue, Twenty-first Street, New York. The system adopted was to first pump up to a pressure of 2,000 lbs., and then to reduce to 1,800 lbs. Thus each filling operated as a test of the cylinder. One of the employées was engaged in filling three 100-foot cylinders with hydrogen, when two of them exploded, hurling fragments of metal in all directions. One man was killed, and two others were severely injured. The filling table was reduced to splinters, holes were blown in the roof, and much general damage done. The explosion was said to be due to negligence on the part of one of the workmen, whose duty it was to watch a gauge to see when the proper pressure had been attained, the pressure probably going far beyond the prescribed limits.

A boy who had been set to fill a gasholder with oxygen at the Royal Naval College, Greenwich, used a holder which had contained oil gas. After filling the holder, he applied a light to the tubes. An explosion followed, breaking one of his arms, and cutting his face and eyes.

On the afternoon of 15th March 1895, an explosion occurred at Fenchurch Street Station, London, which caused the death of a gardener named Holbrook. The unfortunate man was carrying a cylinder, supposed to contain compressed oxygen, which he had just purchased, to his employer's house at Plaistow. While waiting for his train he sat upon one of the seats in the station and laid the cylinder by his side. Shortly after a loud report was heard, and the mangled body of the man was found lying on the platform with one arm completely blown away. The cylinder, which had exploded, had been rent open longitudinally. At the inquest, it appeared from expert evidence that the cylinder must have contained *mixed* gases,—oxygen with hydrogen or coal gas,—and that it had exploded in consequence of the heat evolved by spontaneous combustion of iron filings or grease. It appeared further that the maker of the gas had used an apparatus which was adapted for the compression of both oxygen and hydrogen, and it was conjectured that through some oversight these two gases must have been compressed into the cylinder simultaneously. In passing a verdict of accidental death, the jury recommended that the compression of oxygen and hydrogen, or coal gas, should be kept quite distinct from each other in all respects.

CREOSOTE.

A terrible explosion took place a few years ago, in a creosote still at the works of Messrs Burt, Boulton, and Haywood, at Silvertown, by which eleven men were killed and two injured. The verdict arrived at by the inquest was that the deaths resulted from the "accidental explosion of a creosote still," such having been brought about by the blocking up of the worm in the condenser of the still, and the consequent pressure of the gases thereof.

DYNAMITE.

On 3rd November 1893, the Spanish steamer "Cabo Machichaco," 1,213 tons register, belonging to the Vasco Andulaz Company, arrived at Santander with a miscellaneous cargo consisting of 2,000 tons of iron, 1,810 cases of dynamite (about 47 tons), many cases of petroleum, some barrels of wine, sacks of flour, and other merchandise. Before reaching the quay a fire was discovered, and contrary to regulations the vessel was moored to it; 30 cases of dynamite were quickly removed to a place of safety, this being the quantity which was said to be on board. The agent upon being asked if there was any more of the explosive on board, replied in the negative. The fire on the ship rapidly progressed, and in the meantime the quay became crowded with many hundreds of spectators. In about 2½ hours after the fire was discovered, a most appalling explosion took place, spars, rails, and all sorts of fragments being hurled in all directions, and with such dreadful effect, that 510 persons were killed and about 1,000 cases of injuries, more or less serious, were also reported, while the damage done to surrounding property was tremendous.

A most formidable explosion took place in 1884, near Kimberley, Cape of Good Hope. It appears from the official report of Mr F. Chute, inspector of machinery, Kimberley, that there were exploded on this occasion, of dynamite 68,280 lbs.; potentite, 7,150 lbs.; gunpowder, 16,746 lbs.; making a total of 92,176 lbs. or 46 tons, besides 842 boxes of detonators, and 317,350 sporting cartridges, and 75 cases of paraffin. The magazines containing these explosives were 16 in number, and the shock was felt outside a radius of 20 miles. The only loss of life was three natives. The damage and loss of explosives was about £17,000. The cause of the explosion could not be definitely ascertained.

Nine men (of whom three were killed and six injured) were engaged, some in cleaning out the debris and others in boring additional holes in the sump of a new pit which was being sunk for the Powell's Tillery Steam Coal Company Limited. Nine holes charged with gelatine dynamite had been fired by means of electric detonator fuses about 7½ hours previously. When three of the men were attempting to remove a loosened stone from the bottom by means of a crow bar, an explosion occurred. Most likely an unexploded cartridge remained in the end of one of the holes, and on this being struck by the crow bar, exploded.

The danger to life and property resulting from the conveyance of explosives in contravention to regulations is doubtless of more common occurrence than is generally realised. Some time ago the author had a conversation with an Irishman who rejoiced in the name of "Dynamite Dick," and who made a living by travelling about the country breaking up "iron horses" from blast furnaces, and other massive bodies requiring disintegration, for which purpose he used dynamite. After relating some exciting experiences he had had in his professional capacity, upon being questioned as to the precautions he took for the conveyance of dynamite, he stated that he often carried the explosive as ordinary luggage, and boasted that he had many times carried his store of dynamite packed in a portmanteau with the usual paraphernalia of a traveller, and had placed it on the hat rack of the railway carriage, although it contained sufficient of the explosive to wreck the train should any mishap occur.

Subjoined is an official return of the accidents from the thawing of dynamite in various parts of the United Kingdom to the end of 1893, in regard to which reports have been made by H.M.'s Inspectors of Explosives :—

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
1	Winter of 1871-72	Wheal Agar Mine, near Pool, Cornwall	...	...	...	Some cartridges which were being thawed in the dry house of the mine round the stove exploded and blew the roof off.
2	9th Oct. 1872 .	Chwarel Fawr Quarry, near Carnarvon	2	...	2	The deceased were thawing dynamite on a stove in the weigh house.
3	9th Dec. 1872 .	Cottage at Luxulion, Cornwall	1	6	7	Thawing dynamite in front of a kitchen fire.
4	10th Dec. 1872.	Fowey, Cornwall .	...	1	1	Similar accident.
5	10th June 1873.	Frizington, Whitehaven	...	...	...	A man put a packet of dynamite into a cottage oven to thaw it. House wrecked. No one in the room at the time.
6	10th Feb. 1874.	Airesland, Wigtown .	...	1	1	The injured man was thawing dynamite on a shovel.
7	— Aug. 1873 .	Airyhemming . .	...	2	2	Similar accident.
8	12th Feb. 1875.	Eston, Cleveland .	2	...	2	Dynamite placed near fire to thaw.
9	23rd Feb. 1875.	Mountain Ash . .	1	2	3	Dynamite placed in oven to thaw.
10	— 1874 . .	Avonmouth, Bristol .	...	...	...	Dynamite thawed in a chest by steam not under pressure exploded. This is a curious instance of explosion by exposure to heat not exceeding 212° F., and was probably result of decomposition in the first instance.
11	17th Nov. 1875	Llanbedrog Quarry, Pwllheli	1	3	4	Thawing dynamite on a shovel.
12	1st May 1876 .	Morrisonshaven, Prestonpans	1	2	3	Man put a "warmer" containing dynamite on a smithy fire and blew the bellows. The warmer was a canister in a kettle of water.
13	26th Nov. 1877	Minera Mine, Wrexham	...	1	1	Man thawing dynamite at a candle. Left hand shattered.

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
14	24th Jan. 1878 .	Caermincian Quarry, Llanberis	2	...	2	Thawing dynamite by a fire. One of the men was blowing a bellows at the time.
15	23rd Jan. 1878 .	Dinorwic Quarries, Llanberis	...	1	1	Man warming three primers of dynamite on a stove.
16	4th Dec. 1878 .	Letterwood, Oban .	2	...	2	Thawing dynamite in water (or in a tin in water) over a fire.
17	21st Dec. 1878 .	Talargoch Mine, Rhyl .	1	1	2	Heating dynamite in a tin over a candle.
18	9th Jan. 1879 .	Halkyn, Flint . .	...	...	...	Dynamite exploded while being thawed in a manure heap heated by a steam pipe. Compare No. 10.
19	29th Jan. 1879 .	Newcastle-on-Tyne .	...	3	3	A small vessel inside a metal bucket was being used for thawing dynamite. An explosion took place when the water was heated on a fire, probably through accidental presence of dynamite in the water.
20	29th Jan. 1879 .	Festiniog . . .	...	2	2	Thawing dynamite before a cottage fire.
21	13th Feb. 1879 .	Lochcarron . . .	1	...	1	Man killed in re-heating some water used for thawing dynamite, with which it must have come in contact. Compare No. 19.
22	21st March 1879	Low Hale Colliery, Wigan	...	3	3	Men thawed dynamite in water and threw the water under the grate. The water which contained nitro-glycerine naturally exploded, and the explosion was communicated to other cartridges on the floor. Compare Nos. 19 and 21.
23	14th April 1879	Praze, Cornwall . .	2	...	2	Thawing dynamite before a fire.
24	19th June 1880 .	Glencruitten, Oban .	...	2	2	Similar to 19. The inner can had a hole in it.
25	4th March 1880	Craig, Montrose . .	5	1	6	Explosion of a kettle containing water from a warming pan, in the inner casing of which there was a hole. Compare Nos. 19, 21, 22, 24.

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
26	5th April 1880 .	Hawkesbury Colliery, Bedworth	1	...	1	Re-heating water in which dynamite had been thawed. Compare Nos. 19, 21, 22, 24, 25.
27	1st Dec. 1880 .	Great Pant-y-Pydew Mine	...	2	2	Dynamite put on a hob to thaw.
28	18th Jan. 1881 .	Berehaven Mines .	2	3	5	Dynamite put on a hot iron tube to thaw.
29	15th Feb. 1881 .	Beath, near Kelty .	...	1	1	Man rubbing two cartridges of dynamite together in his hands to complete thawing.
30	1st May 1882 .	United Phœnix Mines, Cornwall	...	1	1	Thawing dynamite over a candle.
31	26th Jan. 1883 .	Glascoed, Llanbaddock	...	3	3	Man put dynamite into an oven to thaw.
32	2nd March 1883	Tunnel, near Bangor .	1	...	1	Thawing dynamite near a fire.
33	29th March 1883	Southrigg Colliery, Airdrie	1	1	2	Dynamite placed to thaw in extemporised warming pan in hot ashes. Probable leak in inner tin, or no water between inner and outer tins. Compare Nos. 19, 21, 22, 24, 25, 26.
34	2nd April 1883 .	South Phœnix Mine, Cornwall	...	3	3	Thawing dynamite near a hot iron tube. Compare No. 28.
35	8th Nov. 1883 .	Plumbley Colliery, Eckington	1	1	2	Dynamite placed under a fire on a pit bank to thaw it.
36	7th Nov. 1883 .	Rhondda Merthyr Colliery, South Wales	...	2	2	Thawing dynamite near fire.
37	7th Nov. 1883 .	Greengairs, Airdrie .	2	2	4	Dynamite placed on a hob to thaw.
38	17th Dec. 1883 .	Cardenden Colliery, Fifeshire	..	1	1	Thawing dynamite on a piece of tin over a lamp.
39	17th Dec. 1883 .	Town Hill Colliery, Dunfermline	1	1	2	Similar accident.
40	3rd Nov. 1883 .	Pumpherston Oil Works, Mid-Calder	...	1	1	Thawing dynamite in his hand before a fire.

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
41	18th Dec. 1884 .	Holywell, Flint . .	...	2	2	Thawing dynamite in a tin before a fire.
42	2nd Jan. 1885 .	Carrickfergus . .	1	..	1	Man holding dynamite to thaw before a fire.
43	1st April 1885 .	New Inn, Rhondda Valley	2	1	3	A man put dynamite to thaw in a saucepan and then into an oven.
44	31st March 1885	Halifax . . .	1	1	2	Man thawing dynamite before a boiler fire or picking at it when hot.
45	8th Jan. 1886 .	Camps Lime Works, Kirknewton	...	3	3	Thawing dynamite in a tin before a fire.
46	12th Jan. 1886 .	Mancetter Bridge (Oldbury) Quarry, Atherstone	1	...	1	Thawing dynamite in a tin over a fire.
47	20th Jan. 1886 .	Railway in course of construction, near Clonakilty, Co. Cork	1	...	1	Blasting gelatine placed in a tin kettle near a fire and either a boy (killed) meddled with it or it became overheated.
48	19th March 1886	Butterton, near Leek .	1	1	2	Gelatine dynamite put in an oven to thaw.
49	9th April 1886 .	Craven Moor Lead Mine, Pateley Bridge, Leeds	1	...	1	Thawing dynamite over a candle.
50	8th Nov. 1886 .	Raisby Hill Quarries, Durham	...	1	1	Thawing dynamite in front of a fire.
51	8th Jan. 1887 .	Railway in course of construction at Ballintubber, Co. Wexford	3	...	3	Man placed can containing dynamite and water on fire.
52	12th Jan. 1887 .	Railway in course of construction at Ballintubber, Co. Wexford	...	...	...	Man placed can containing dynamite and water on fire.
53	13th Jan. 1887 .	E. Romans Mine, Shropshire	...	3	3	Man placed can containing dynamite and water on fire.
54	27th April 1887	Quarry at Worrall, near Bradfield	...	5	5	Throwing dynamite on hot shale close to a fire.

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
55	12th Nov. 1887	Barry Railway, nr. Cardiff	1	...	1	Thawing dynamite in a metal can over a fire.
56	16th Jan. 1888.	Ratcleuch Quarry, near Alnwick	1	...	1	Carrying dynamite in a bucket of hot ashes.
57	29th Feb. 1888	Bolts Burn, Rookhope, Durham	1	...	1	A cartridge of gelatine dynamite left in pocket of trousers which were hung to dry before the fire.
58	16th March 1888	Melyn Tin Works, Neath	1	...	1	Kneading dynamite placed to thaw on hot cinders.
59	17th Dec. 1888.	Pencoed, Llanelly	2	1	3	Thawing dynamite in a bucket over a fire.
60	13th Feb. 1889.	Pentrebach, Old Iron Works, near Merthyr	1	...	1	Thawing dynamite in a metal can on or near hot cinders.
61	23rd Feb. 1889.	Cwm Mawr Mine, Merioneth	...	1	1	Boiling dynamite with water in a can over a fire.
62	5th Feb. 1890.	Burradon . . .	...	4	4	Thawing dynamite in a can of water placed in an oven.
63	18th Feb. 1890.	Colwill Quarry, near Egg Buckland, Co. Devon	2	...	2	Thawing dynamite by steaming it in an old straw hat placed over hot water containing nitro-glycerine.
64	— March 1890.	Moss Bay Iron Company's Works, Maryport	1	1	2	A man put about 5 lbs. of dynamite on stove, and 60 more cartridges before fire. He was under the influence of drink at the time.
65	4th July 1890.	Bonnyside Fireclay Mine, Bonnybridge, Stirlingshire	...	1	1	A man was engaged in heating water for thawing dynamite, which had previously been used for that purpose, when an explosion took place.
66	26th Nov. 1890	Radyr Quarry, Llandaff	2	1	3	A man thawed dynamite in bucket of water, and then put the dynamite into a proper warming pan and filled up the outer case of the pan with water from the bucket. Some time afterwards another man, in ignorance of what had been done, put the water from the outer casing of warming pan into a bucket and placed it on the fire to heat. An explosion immediately took place.

No.	Date.	Place.	No. of Killed.	No. of Injured.	Total No. of Casualties.	Remarks.
67	9th Jan. 1891 .	Creagmore House, Kilmakie, Inverness-shire	2	2	4	Some blasting gelatine cartridges were put into a canister which was placed into a kettle on kitchen fire.
68	19th Dec. 1891 .	Navigation Sinking Pits, near Pontypridd, Glamorganshire	...	2	2	Some water, which had previously been used for thawing dynamite, was put into a tea kettle. The water is supposed to have contained nitro-glycerine. There is said to have been a leak in the warming pan.
69	16th Jan. 1892 .	18½, Bute Town, Pont-tottyn, Merthyr Tydvil	...	1	1	Two dynamite cartridges placed in an oven.
70	27th Feb. 1892 .	Penrhiewfer Colliery, near Dinas	3	...	3	Thawing dynamite in a tin over a paraffin lamp.
71	23rd Feb. 1893 .	Machine House of Mr Lewis Thomas, Wern Colliery, Pontypridd	...	2	2	Some dynamite cartridges placed on a shovel over the fire to thaw them.
72	6th Nov. 1893 .	Scot Hay, near Silverdale	2	1	3	Tin canister of gelatine dynamite placed in oven boiler to thaw them.
		Total . .	60	87	147	Each "accident" therefore, on an average, killed or wounded two persons.

For the avoidance of such accidents in the use of gelignite, gelatine dynamite, dynamite, and blasting gelatine, the following instructions have been issued by Nobel's Explosives Company Limited of Glasgow, who point out that cartridges of the compounds just named become congealed during cold weather even at a temperature so high as 45° F., and that this may occur without altering the soft and plastic outward appearances of the cartridges.

DIRECTIONS FOR USE OF EXPLOSIVES IN COLD WEATHER.

All cartridges before blasting should be heated in warming pans. Specially designed warming pans should alone be used for this purpose, and in them the cartridges can be kept in a proper usable condition for several hours in the coldest weather.

On no account expose cartridges to the direct heat of fire, or place them on a hot stove or warm piece of metal, or on a steam pipe. Do not attempt to heat them by these or any other irregular means, or accidents thereby will inevitably occur.

There should be no fire, &c., in the hut or apartment in which the thawing is conducted.

One cartridge at a time should be gently pressed, not forced, to the back of the bore-hole, and great care should be taken to avoid jamming or "bunching."

Warming pans, specially constructed, are supplied by the Agents of the Company at nominal prices.

DETONATORS.

Two girls in the employ of the Nobel's Explosive Company, at West Quarter, were engaged in conveying a truck containing some semi-manufactured detonators and some detonator composition from the magazine to the working shed. They left the truck and began waltzing together, and during their "larking" they unhappily stumbled and upset the truck, causing the explosion of the whole of its contents, with the result that the girls were shattered to pieces.

ETHER.

Dr Averill, a surgeon in North Staffordshire, while in the act of pouring some sulphuric ether into a phial out of a five-pint bottle, upset some of the liquid near a fireplace; the ether became ignited, and a loud explosion followed, the unfortunate doctor being severely burned, the house terribly shaken, and all the bottles in the surgery shattered to fragments.

FULMINATING CAPS (AMORCES).

These small detonating caps (*see* p. 179) used by children with toy pistols, are a fruitful source of serious accidents.

A terrible explosion of toy fulminating caps took place in the Rue Beranger, Paris, in 1878. Six to eight millions of these small caps, done up in rows of five and pasted on strips of paper, were piled up in a store, in boxes containing a gross each. By some unknown accident one individual cap was set off, and started the rest, and in less than a minute the house was shattered to the ground by the violence of the explosion which resulted. A stone, a metre cube in size, was hurled through the air to a distance of 52 metres, and a large portion of the adjoining premises was also wrecked. This explosion caused the death of fourteen persons, and sixteen others were more or less seriously injured. It appears there were two qualities of caps in the pile, known as single and double, and having the following compositions:—

Single.

Potassium chlorate - -	12 parts.
Amorphous phosphorus -	16 ,,
Lead oxide - - -	12 ,,
Resin - - - -	1 ,,

Double.

(More sensitive to friction than the single.)

Potassium chlorate -	9 parts.
Amorphous phosphorus -	1 ,,
Antimony sulphide -	1 ,,
Sulphur, sublimed -	0.25 ,,
Nitre - - - -	0.25 ,,

A characteristic fatal accident with amorces took place at Vannes some time ago. It appears a child was amusing itself by detonating the caps between the blades of a pair of scissors. Two packages of 600 caps each were lying on a table close at hand. These suddenly exploded and killed the child, and considerable damage was done to the apartment.

PACKING OF DRUGS AND CHEMICALS.

It is surprising that accidents in the conveyance of goods of this description are not of more frequent occurrence. The following chemicals are commonly purchased in small lots, and oftentimes packed for transit in straw, two or more in the same box:—Ether, Nitric Acid, Sulphuric Acid, Benzol, Chlorate of Potash, &c. Should a box with such contents receive a concussion sufficient to break the bottles, an explosion would ensue only to be compared in intensity to the bursting of a bomb. Such chemicals are daily in transit about the country for doctors, analysts, druggists, science and art laboratories, &c., in boxes simply labelled "Acids.—This side up.—Glass, with care." They often receive rough usage from porters, and sometimes little attention is paid to the wording on the labels.

Nitric and sulphuric acids should never be enclosed in the same package, or loaded with other chemicals. Nitric acid should be packed in ashes or sand, or other material upon which the acid has no action. Ammonia liquid must not be enclosed in the same package or loaded with acids, or with bromine.

FLOUR-MILL DUST.

A terrible explosion of flour-mill dust and atmospheric air took place recently at the large flour mills of Messrs Köhler Brothers, St Louis, U.S.A., which resulted in the loss of several lives, as well as the wrecking of the premises and about forty dwellings in the immediate neighbourhood. It appeared that a fire was discovered in a part of the mill at half-past three in the morning, and spread beyond control. When the fire reached the pent-up mill dust, a tremendous explosion occurred, and in a moment the immense structure collapsed. The concussion was felt for miles around, and two elevators on the opposite side of the street, containing 20,000 barrels of flour and 200,000 bushels of wheat, were ignited by the flaming fragments hurled through the air, and were burned to the ground.

GASOLENE.

When air is passed through a chamber containing this highly volatile and inflammable liquid, a considerable quantity is vaporised or dissolved by the air, and this mixture can be burnt in the same manner as coal-gas, giving a brilliant white light. There have been numerous attempts to devise simple arrangements for making this gas for lighting country houses, &c., and many fatal accidents have resulted from carelessness in handling what is a most dangerous liquid.

On one occasion a servant-girl went into a cellar with a lighted candle where was one of these miniature gas-making machines at work, and immediately a loud explosion took place, resulting in the death of the girl and the destruction of the house by fire. There was a leakage of the vapour of gasolene, which being mixed with a large quantity of air formed an explosive compound.

GUNPOWDER.

On 12th May 1876, at the factory of the East Cornwall Powder Company, Herodsfoot, an explosion of gunpowder took place, resulting in the loss of three lives, accidental ignition taking place during the breaking-up of "press cake" with a wooden mallet, the friction due to the presence of grit producing the necessary temperature. Another explosion occurred in the same factory by the improper use of a chisel to remove some indurated powder cake from the rollers of a granulating machine. These accidents illustrate that it is not necessary to apply a spark or flame in order to ignite gunpowder, and too much care cannot be exercised in reducing any friction to a minimum in handling gunpowder or other explosive.

On 11th May 1877, at the factory of M. Carl Henser, Lochfyne, while a quantity of gunpowder was being conveyed in a cart it exploded, causing the death of the man and horse. It appeared that there was a hole in the bottom of the cart, through which some powder would escape to the ground, and the horse travelling backwards and forwards on the same track would consequently tread with his iron shoes on the train of powder. The friction thus created was sufficient to ignite the powder on the ground, which in turn exploded the powder in the cart, either by its own force or by igniting the train of powder passing through the hole.

A singular explosion is recorded as occurring in 1880 in the fire-box of the locomotive of a night express between Leicester and Derby, immediately after the stoker had fed the fire with coal. The explosion, which was violent enough to severely injure the driver and stoker, appeared to be due to gunpowder, and was no doubt caused by a charge of powder in a piece of coal which had escaped being fired in the pit during mining operations.

A serious explosion of gunpowder took place on 26th April 1881, in H.M.S. "Doteril," resulting in the loss of 143 lives and the destruction of the ship. The accident took place while the vessel was at anchor off Sandy Point, in the Straits of Magellan, at about 10 A.M., and consisted of two distinct explosions. The first was thought to be an explosion of gas emanating from the bunkers, which in turn caused an explosion in the powder magazine. Another conjecture as to the first explosion was that it was produced from a drier known as Xerotine Siccative, which is composed of resinous water and highly volatile and inflammable petroleum spirit, and which was confined underneath the paint-room.

On 7th June 1882, during a marriage celebration at Brynmally, near Wrexham, a cannon overcharged with gunpowder was fired, and burst into several pieces, some of which struck two brothers named Ellis, killing them on the spot.

A disastrous explosion took place at midnight in a coal-mine at Sturgis, in Kentucky, when five kegs of blasting powder exploded with terrible effect, five miners being killed and many injured. The mine was caved in.

During some blasting operations at the Canada Docks Extension Works, Liverpool, one of the cartridges used missed fire. Two labourers, named Caughay and Patrick Connolly, went forward to examine the unexploded charge, which unexpectedly exploded, killing them both on the spot.

During a thunderstorm in July 1893, a powder-house at Buffalo, U.S.A., which contained fifty kegs of blasting powder, was struck by lightning and exploded, the building being shattered to atoms. Fences, rails, stones, and bricks were scattered for half-a-mile, seriously damaging neighbouring tenements. The telephone system was disabled throughout the city, and the electric lights were extinguished.

Some time ago, as two men were shooting with a rifle in Indiana, a stray bullet entered the powder-house of Messrs Schaeffer & Schaeffer. An explosion quickly ensued, which blew both men to pieces; houses were wrecked in the vicinity, and several persons injured.

INDIARUBBER SOLUTION.

A can of rubber solution was stored in the hold of one of the L. and N.-W. Railway Company's steamers, having no better covering than a piece of canvas, tied by a string at the top, which allowed vapour of benzol or naphtha—the solvent usually used for rubber—to escape. The result was the breaking out of a fire which, fortunately, was extinguished before any serious damage was done.

A serious fire, which took place on 13th October 1890, on the premises of a firm of hat and helmet makers, Clothfair, London, and resulted in the loss of eight lives, had its origin in carelessness in the manipulation of indiarubber solution. It appears that some of the substance was being tested on a stove near a lighted gas jet, when the naphtha vapour, emanating from the solution, took fire. This was the beginning of a most serious conflagration. The premises being unlicensed, the firm were prosecuted for contravention of the Petroleum Act, and fined £30. A fine of £20 was also imposed for the unlicensed storage of naphtha on another portion of the premises. The coroner's jury, in bringing in a verdict of accidental death, found also that the firm were deserving of severe censure for the dangerous manner in which their business was conducted.

LAMP ACCIDENTS.

The following instances are selected from a vast number of serious and fatal accidents which have occurred with petroleum, benzoline, or paraffin lamps :—

A Mrs Turner, of Peckham, was sitting reading by the light of a penny oil lamp, which by some means got upset, and the oil running out, became inflamed, and set fire to the unfortunate woman's clothing, which resulted in her death.

Firemen were summoned to 39 Cadogan Street, Chelsea, at two o'clock in the morning, owing to a serious fire which was produced by the upsetting of a benzoline lamp. Mrs Annie Colson was so injured that she died in the hospital shortly afterwards. The contents of one room were completely burnt.

A woman was carrying a lighted paraffin lamp in a draughty passage, the lamp exploded, and in the resulting fire, the unfortunate woman was burnt to death.

A young girl in Bermondsey was reaching something from a mantelpiece when her arm caught a lighted lamp and knocked it over. Her clothes immediately ignited, and she was burnt so severely that she died in Guy's Hospital from the effects.

A woman, after reading in bed with a light from a paraffin lamp, turned the wick down in order to extinguish it, the wick slipped into the reservoir of oil, and the lamp exploded, and the resulting fire burned the unfortunate woman to death.

Sarah Ann Calvert, aged thirty-five, the wife of a dustman in the employ of St Luke's Vestry, died at St Bartholomew's Hospital from severe burns. When going to bed, the unfortunate woman blew down the chimney of a common paraffin lamp, which caused an immediate explosion. The glass reservoir burst in all directions, Mrs Calvert's night-clothes were saturated with the oil and set on fire, and she died from the injuries received.

A young lady, Miss Holderness, of Marlborough Place, Brighton, before retiring to rest one night, blew down the chimney of a lighted lamp in order to extinguish it. An explosion took place, the resulting flaming oil set fire to her clothes, and she was burnt to death.

A woman at Salford was going upstairs at night with a lighted paraffin lamp when she fell backwards. The lamp was smashed, and the resulting conflagration burned her to death.

A man in Birmingham, whilst under the influence of drink, caused the death of his wife by throwing a lighted petroleum lamp at her.

At Fulham a woman endeavoured to make a fire burn by pouring oil upon it from a petroleum lamp. The oil immediately flared up, breaking the reservoir of the lamp, and setting her on fire. She was so severely burnt that she died soon afterwards.

A lighted lamp which a woman was carrying downstairs at Clayton-le-Moors suddenly exploded, and in the fire thus caused, the woman was burnt to death.

At Sheffield, a lamp standing on a small table suddenly exploded, though not touched by any one, and the burning oil thrown upon the clothing of a woman and her child, caused the death of the latter.

At Bangor, a woman attempted to extinguish a lighted lamp by blowing down the chimney. An explosion resulted, and she died from burns.

A lamp left burning in a house in Elton's Yard, Salford, exploded, and the burning oil caused the death of three children.

At Burnley, during a quarrel between three women, one of them picked up a lighted oil lamp and threw it at the other two, causing their deaths.

A man died at the London Hospital from burns received by the explosion of an oil lamp at a house in Bethnal Green. Before his death, the man stated that he was moving a lamp from a table when it exploded, and set him on fire.

At Eastbourne, a young woman was reading in bed by the aid of a lighted lamp which she held in her hand, when she fell asleep, and dropping the lamp, was burnt to death.

At Kilburn a woman, whilst carrying a lighted lamp, was seized with a fit of coughing which caused her to drop the lamp. The oil from the broken reservoir took fire, and she was burnt to death.

During a quarrel in a house at Bristol, a young man threw a lighted lamp at a neighbour, and afterwards falling over it himself, set his own clothing on fire, and died in great agony.

At Ipswich, a servant girl attempted to fill a metal oil stove while it was alight, while the oil in the can she was holding suddenly took fire and enveloped her in flames. She died the same day.

At Aston, a woman turned the wick of a lighted lamp down low and blew down the chimney. An explosion followed, and the woman was burnt to death.

An old lady, aged seventy-three years, was burnt to death at Muston, Leicester, in December 1893, by the upsetting of a paraffin lamp.

Two lives were lost at Clerkenwell on 9th December 1893, by the upsetting of a paraffin lamp. At the inquest on the bodies, the coroner urged the use of metal in place of glass reservoirs for lamps burning highly inflammable oil.

During the year 1894 there were 3,061 fires in London, resulting in the loss of 82 lives; 337 of these fires were produced by the upsetting of mineral-oil lamps, and 90 from the exploding of mineral-oil lamps. Of the 82 deaths, no less than 32 were caused through these lamp accidents. Under these circumstances, it is not surprising that the question of the supply of safe mineral oils and lamps for the people is at present engaging the serious consideration of the Government departments, petroleum experts, and traders.

Many experts are of opinion that the minimum flash point —viz., 73° F., as stipulated in the Amended Petroleum Act of 1879—is too low, and that 100° F. would be the safe figure to adopt with the Abel flash point apparatus; while others are of opinion that it is the lamps that are at fault. No doubt much can be said on both sides, but there is no necessity (in the writer's opinion) to fix the minimum flash point so high as 100° F., especially in consideration of the fact that the majority of lamp accidents are caused by them being knocked down and broken, or upset. No doubt many of the lamp explosions might be traced to the sale of oils in contravention to the provisions of the Petroleum Act; and in all cases of lamp explosions, a similar sample of oil to that used in such lamps should be obtained if possible, and tested, and the name of the trader who sold the oil ascertained.

There can be no question that an oil flashing at 100° F. would be safer to store and manipulate than one flashing at 73° F., but the writer is of opinion that if the minimum flash point were fixed at 85° F., and metal lamps of approved construction universally used, with properly fitting wicks, lamp accidents would be reduced to a minimum,—provided, however, that strict observance of the provisions of the Petroleum Act were insisted upon.

A recent experience of the writer's strongly enforced the lesson of the greater safety of metal lamps. One evening a maid-servant, who was laying the table for dinner, accidentally hit with a carving-knife the glass reservoir of a lighted lamp which was standing on the table. The glass on one side of the reservoir being smashed, the whole of the oil was let out on the table. The lamp, however, continued alight, and before one could realise the situation the girl very courageously rushed to the lamp, and *blew down the chimney*. To our surprise and satisfaction the light was safely extinguished, it appearing from subsequent examination that the oil in the lamp was kerosene of high flash point. Had it been oil flashing at 73° F., with the temperature of the room up to 68° F., the consequences would doubtless have been serious.

The writer's attention has recently been called to the question of the quality of the oil supplied for colliers' safety-lamps, and he may here set out an article communicated by him to the *Colliery Guardian*:—

"The writer recently had occasion to examine a number of samples of burning colza oil proposed to be used in miners' safety-lamps at some important collieries. Now, burning colza oil is ostensibly a mixture of pure colza or rape oil with a light mineral oil, preferably kerosene of high flash point, in such proportions as is suitable to the kind of lamp and wick used. The principal object of the addition of the hydro-carbon oil is to reduce the viscosity of the colza, thereby increasing the capillary action of the wick, pure colza being generally too viscous for the purpose. Out of about a dozen samples of oils examined, the amount of mineral oil varied from 5 to 60 per cent. This is very irregular, not to say dangerous, especially in cases where the lowest tender is accepted. One sample had a flash point as low as 114° F. It will thus be seen that the term 'burning colza oil' is a very ambiguous one; and in asking for quotations it is desirable that colliery owners should qualify it, stating the quality and proportion of mineral oil necessary to be mixed, or perhaps a better plan would be to order pure colza or rape oil, and have it mixed with the requisite quantity of approved mineral oil at the colliery. The proportion of mineral oil must depend upon the kind of lamp and wick used, and local considerations must also be taken into account, such as temperature of the mine, &c. For instance, the writer made a mixture of 80 per cent. of pure rape oil with 20 per cent. of kerosene, specific gravity .825. A quantity of the mixture was sent to two collieries, one of which was damp and well-ventilated, and the other a dry, dusty, and fiery mine. The overman of the damp mine stated the mixture to be excellent, while the dusty mine overman reported the oil to be unsuitable, causing a smoking flame. In each case a Howat's patent safety-lamp was used, and similar quality of wick. Too much care cannot be exercised in selecting safe oils for colliers' lamps, and while it is not intended to give alarmist views on the subject, the writer has practical reasons for believing, that it is not improbable that one of the causes of the too frequent explosions may be due to the indifference displayed as to the nature and quality of the oils sent to the mines."

Construction of Petroleum Lamps.—The following are the instructions issued by the London County Council as to the construction and management of ordinary mineral-oil lamps:—

(A.) *Lamps.*

(1.) That portion of the wick which is in the oil reservoir should be enclosed in a tube of thin sheet-metal, open at the bottom, or in a cylinder of fine wire-gauze, such as is used in miners' safety-lamps (28 meshes to the inch).

(2.) The oil reservoir should be of metal rather than china or glass.

(3.) The oil reservoir should have no feeding-place or opening, other than the opening into which the upper part of the lamp is screwed.

(4.) Every lamp should have a proper extinguishing apparatus.

(5.) Every lamp should have a broad and heavy base.

(B.) *Wicks.*

(1.) Should be soft, and not tightly plaited.

(2.) Should be dried at the fire before being put into lamps.

(3.) Should be only just long enough to reach the bottom of the oil reservoir.

(4.) Should be so wide that they quite fill the wick-holder without having to be squeezed into it.

(C.) *Management.*

(1.) The reservoir should be quite filled with oil every time before using the lamp.

(2.) The lamp should be kept thoroughly clean. All oil should be carefully wiped off, and all charred wick and dirt be removed, before lighting.

(3.) When the lamp is lit, the wick should be first turned down, and then slowly raised.

(4.) Lamps which have no extinguishing apparatus should be put out as follows:—The wick should be turned down until there is only a small flickering flame, and a sharp puff of breath should then be sent *across* the top of the chimney, but not *down* it.

(5.) Cans or bottles used for oil should be free from water and dirt, and should be kept thoroughly closed.

LIME OR QUICKLIME.

Owing to the intense heat developed when water comes in contact with lime, many accidents have resulted from its careless storage.

Milk of lime, or lime-wash, is used to paint the inside of cattle vans, the wash being prepared by "slaking" the lime with water, and diluting to the desired consistency. A singular accident which came under the writer's observation took place upon an English railway. It appeared that a cattle-van had been white-washed, and that the lime used had not been properly slaked, lumps of unslaked lime being distributed over the bottom of the van. The van was used to convey some pigs to London, and when they arrived it was found that some of them were severely burnt, consequent upon the heat developed by the action of their liquid excrement upon the unslaked pieces of lime. Damages were claimed by the owners of the animals.

A cartload of lime, exposed to the air, was being conveyed to the scene of some building operations, and was caught in a shower. The heat developed during the consequent slaking was sufficient to set the cart on fire. Numerous instances of fires under the like circumstances are reported.

A fire was caused on board the steamer "Leerdam" by the accidental slaking of lime in a barrel in which eggs were packed.

During a gale in Mobile Bay, in September 1860, the waters from the bay were "sprayed" into various parts of the city by the wind, and found an entrance into warehouses where lime was stored. The slaking of the lime caused sufficient heat to start a great conflagration, which consumed about 500,000 dollars worth of property.

Seventeen fires are reported as caused in London in 1894 through the slaking of lime in contact with combustible bodies, eight of these fires being caused by slaking with rain.

MATCHES.

A remarkable accident resulted near Bournemouth from carrying a box of safety-matches and potash lozenges in the same pocket. A Mr Tiddell, of Winton, placed a box of matches in the pocket where he usually carried lozenges for the relief of asthma. A series of small explosions resulted, setting fire to the unfortunate man's clothes, and severely burning his legs. The cause of the accident was doubtless due to the action of the chlorate of potash upon the amorphous phosphorus which is a constituent of the igniting surface on safety-match boxes.

The igniting surface of safety-match boxes is usually made up of 10 parts of amorphous phosphorus, 8 of oxide of manganese or antimony sulphide, and 3 to 6 of glue.

A steamer was recently loaded at Hamburg with a number of cases of safety-matches, and upon arrival at her port of destination it was found that some of them had been on fire, the woodwork of one being charred *inside.* The vessel had a considerable quantity of gunpowder on board, but fortunately the fire must have been extinguished by the products of combustion in the confined space, otherwise the consequences would have been serious.

Some years ago a serious fire occurred in Spital Street, London, as the result of a stone being thrown from the street into a chandler's shop coming into contact with a parcel of lucifers, knocking it to the floor. The matches ignited, and started a conflagration which speedily destroyed the premises.

On one occasion a fire was caused by a current of air from an open window blowing a match case from a table to the floor, when the friction produced caused ignition.

A number of serious and fatal fires have been traced to children playing with matches, and many cases of poisoning through sucking them. Putting a hot tobacco pipe in the same pocket with a box of matches is a very frequent source of fire upon the person, often resulting in severe burns.

No less than 98 fires were reported in London in 1894 as caused by the ignition of matches; 86 of them resulted from children playing with these useful but dangerous articles.

During the investigation of the origin of a serious fire in Cannon Street, London, some years since, which was believed to have arisen from the spontaneous ignition of matches, the late Dr Letheby's opinion was requisitioned. In his examination he said:—"I am professor of chemistry at the London hospital. I procured samples of the different kinds of lucifer matches sold at the defendant's warehouse. I now produce some, but not *the whole*, as some of them *spontaneously ignited as they lay on my laboratory table.* I have analysed the chemical materials of which they are composed, and find them to be chiefly phosphorus and chlorate of potash, glue, and red oxide of iron. I have made experiments for the purpose of ascertaining the conditions under which they will probably ignite, and find that the phosphorus, itself one of the chief constituents, takes fire spontaneously when in a fine powder and exposed to the air. The temperature of this or any other room is sufficient to fire phosphorus spontaneously when in a powdered state, and it may be in a powdered state on the surface of the lucifers. [The witness here put a small quantity of phosphorus on a sheet of paper, and in the course of a few minutes it ignited.] When I put this liquor on a piece of paper it evaporated, and there was left a fine powder which ignited spontaneously. I then made another experiment with the lucifers. I exposed them to a temperature of 140°, and found that they then fired. Such a temperature is very likely to exist in a window in summer time unless the atmosphere is excluded, and then it requires a higher temperature, namely that of 220° F. Slight friction will also set lucifers on fire; for example, the shaking of a parcel containing them, or the box being knocked down by rats or other cause."

METHYLATED SPIRITS.

At one of the principal towns in Lancashire an empty methylated spirit cask was being delivered by a railway van, when the vanboy, contrary to regulations, began to smoke. He was at the time sitting on an empty cask, and when about to throw away his match, the open bunghole of the cask caught his eye, and on the impulse of the moment he slipped the match into the bunghole. The result was an explosion, in which the boy, much to his surprise, was lifted into the air and hurled over the side of the van on to the pavement, sustaining serious injuries.

Empty casks originally containing highly inflammable and volatile liquids should be completely drained before being returned, and the bunghole securely plugged. No light should be taken into a confined shed or warehouse where a number of barrels are stored from which inflammable vapours may emanate. A mixture of inflammable vapour and air is highly explosive.

A game of snapdragon was being played by a number of boys at the Royal Surrey County Hospital, Guildford, one Christmas night, when one of the entertainers threw a quantity of methylated spirit on the dish. The resulting flames caught several of the party and set their clothes on fire, and one boy ultimately died from the injuries he received.

NAPHTHA.

Three labourers were kindling a fire in a railway hut at the terminus of the Caledonian Railway, Glasgow. One of them lifted a gallon-jar of naphtha, and poured some of the contents on the fire, causing an explosion. The burning liquid was scattered all over the men, injuring them terribly.

At a London goods station, upon a can of naphtha in a truck being found to be leaking, a porter entered the truck with a lighted lamp, when the naphtha took fire, but was extinguished before serious damage was done.

A man in Birmingham poured some naphtha down a kitchen flue to clear it. An explosion naturally occurred, which resulted in the death of the man.

A serious explosion occurred in buildings used as naphtha stores at Riga, in September 1893. The buildings and contents were much damaged, and all the windows in the vicinity shattered. When the firemen entered the building with lighted torches, a second explosion was produced, causing serious injury to fifteen persons.

James Hoyle, of Radcliffe, placed a light near the bunghole of an empty cask that had contained "finisher's softening." An explosion ensued, which threw the unfortunate man violently against some machinery hard by. His skull was fractured, and he died from the effects of the injuries. It appeared that the barrel had contained naphtha prior to the "softening."

A serious explosion of naphtha-vapour and air took place in some sewers at Rochester, New York. It appears that a quantity of naphtha—stated about 15,000 gallons—found its way into the sewers through carelessly laid piping. By some means the vapour exploded. Four men were killed and twenty wounded, and four large mills were set on fire, and the whole sewer system of the city was more or less injured.

NITRIC ACID (Aqua Fortis).

Whilst a train was passing through a station a truck was observed to be on fire. The train was stopped, and the truck, which proved to be loaded with carboys of nitric acid, was put off, and the fire extinguished. The contents were destroyed, and the truck considerably damaged. No doubt one of the carboys had leaked, and the action of acid upon the wood resulted in the development of sufficient heat to start ignition.

An explosion, accompanied with a fire, resulted from the breakage of bottles containing nitric and sulphuric acid packed in sawdust in a wooden box. Here the heat which was developed, consequent upon the dehydration of the nitric acid and sawdust, together with the production of nitro-cellulose, set up conditions highly favourable to serious explosion. Acids, as already remarked, should be packed separately, and not in sawdust or other inflammable material, but in sand or ashes.

NITRO-GLYCERINE.

In July 1894, the three brothers Van Buren went to their magazine, near Semple's station, on the Pittsburg and Western Railway, to get a load of nitro-glycerine for the purpose of "shooting" an oil well. They were engaged in loading a waggon with the nitro-glycerine, when by some means it exploded. One of the brothers was blown to atoms, only a part of one leg being found. Three horses attached to the waggon were also blown to fragments, while only a few pieces of the waggon remained. The other brothers, though near by, escaped injury.

NITROUS OXIDE (Laughing Gas).

A young girl went to a dentist to have her teeth attended to, and was placed under the anæsthetic influence of the gas, and while recovering from its effects she had a fatal attack of syncope. It appears the girl was a victim to that harbinger of death—tight-lacing, and it is very probable that this may have had something to do with the fatality. Freedom in breathing is absolutely necessary while a patient is under the influence of an anæsthetic, and women who "tight lace" should not "take gas" or any other anæsthetic.

Two men were shooting rubbish on to a new road in the course of formation at Notting Dale, and came across an iron bottle which contained nitrous oxide gas. Seeing that there was brass about it they thought they would melt it off, and forthwith put it on a fire while they were having breakfast. The intense pressure produced by the expansion of the gas soon exploded the bottle, and severely injured the two men.

OILY WASTE.

Some time ago the writer was commissioned to inquire into the cause of a fire which took place in the tender of a locomotive. It appeared that the tender, contrary to regulations, had contained coal while being retained in a shed for repairs. A watchman going his rounds on a Sunday morning found the coal in the tender in flames. These were speedily extinguished, otherwise the consequences might have been serious. There was no apparent cause for the fire, no spark or flame of any kind having been observed near the tender. On examination of the residue of coal in the tender on the morning following the fire, masses of half-consumed oily waste were discovered intermingled with the coal, and there can be no doubt that the fire originated from the spontaneous combustion of the oily waste which some careless cleaners had thrown into the tender.

No doubt many serious fires, the origin of which cannot be traced, have been due to carelessness or ignorance in the disposal of dirty and oily combustible fabrics of various kinds.

Some years ago the chair factory of Long Bros., of Louisville, Kentucky, was burnt to the ground, through the spontaneous ignition of some oily rags. There had been no fire in the building on the day of the conflagration, it being Sunday. The fire was discovered at midnight in the paint-room, and it appeared that the boys employed in that room were in the habit of throwing oily rags into a barrel kept for the purpose, and usually dumped into a brick receptacle, for use in starting fires under boilers. The precaution had not been taken on this occasion, but the rags had been thrown about the shop, and hence the fire.

In an English factory a quantity of oily fabrics and mill sweepings were piled in a corner of a wooden shed in the course of the evening, and by the morning a fire was discovered which burned the shed to the ground. No lights or fire was hard by; the fire evidently originated from spontaneous combustion of the oily waste.

The conflagration which destroyed a building known as

Swarthmore College, was (according to the *Chemical Review* of October 1883) at first supposed to have originated in the laboratory; but there is good reason to believe that it broke out in an unused loft, where workmen who oiled the balusters, &c., had carelessly thrown their waste rags.

In 1883 a serious fire broke out at the stores of the Dublin Custom-House, which involved a loss of property amounting to £300,000. The cause of the conflagration was shrouded in mystery, and a reward of £1,000 was offered by the Government for information as to how the fire originated, but no clue could be obtained. An inquiry was then held, and it was ascertained that at the time of the fire the store contained a number of bales of carded Leghorn rags, some of which had been used by porters to wipe their oily hands, thirty-six bales of cotton wick, and a large quantity of tallow, palm-oil, wool, cotton, and hemp. It was held that with these materials stored together there was ample cause for the fire to have originated from spontaneous combustion. In the writer's opinion, a warehouse containing such a collection would be one of the most hazardous risks an insurance company could be associated with.

PEROXIDE OF SODIUM.

An explosion which resulted in a fire took place in March 1893 at the Midland Railway London Goods Depot in Whitecross Street. It originated in a wooden box containing peroxide of sodium packed in tin cases. The fire was extinguished before any serious damage was done. An inquiry, however, was instituted by the Home Office as to the cause of the explosion and the nature of the peroxide, with a view to the issue of regulations for safe packing and storage. In the result of the inquiry, it appeared that some of the tins must have been faulty, and that some of the peroxide had leaked into the wooden box, which was most likely damp. These circumstances would be sufficient to account for an explosion followed by ignition.

For the properties of peroxide of sodium, *see* page 19; and for mode of packing, page 308.

PETROLEUM.

(*See also under* LAMP ACCIDENTS.)

A firm had a considerable quantity of petroleum stored on the railway company's premises, where it was pumped into the firm's road tank waggons. During such an operation a considerable quantity of the oil is sometimes spilled, and on one occasion the spilled oil took fire, with the result that a considerable amount of property belonging to the firm and to the railway company was destroyed.

In June 1892, the vessel "Petrolea," laden in bulk with crude petroleum, blew up on the river Gironde, about twenty-eight miles below Bordeaux, with the result of the loss of sixteen lives and three serious injuries. The cause of the calamity could not be discovered.

In November 1891, the steamer "Lux," containing a bulk cargo of refined petroleum, was completely destroyed by fire, and out of twenty-six persons on board twenty lives were lost. The origin of the conflagration was traced to the ignition of some of the petroleum which had leaked in or about the stoke-hole. The vessel was stated to be defectively designed.

Some empty petroleum barrels having been placed outside a goods shed alongside a railway siding, a passing locomotive emitted some live sparks, which found their way into the casks through the uncovered bungholes, and a fire resulted which burned down the shed.

Many serious conflagrations have resulted from sparks from locomotives alighting upon combustible bodies, such as hay-ricks, and many an American forest has been consumed by fire from the same cause. This danger is now considerably minimised by the employment of "spark arresters" upon the engines.

According to a newspaper paragraph issued by the *Central News*, the American liner "Kenilworth" landed at Liverpool eight of the crew of the oil-tank steamer "Alleghany," of Shields, which, when laden with petroleum, had been sunk by colliding with the Belgian vessel "Caucus." The crew of the "Alleghany" made for the rigging before the vessel foundered, and as she went down the head light exploded, causing the petroleum, which was rushing out of the tank into the sea, to become alight, and there was a sea of fire of terrible grandeur. The crew, numbering thirty, fortunately got away.

Early in 1893 a most serious explosion from petroleum, followed by fire, took place at Alton Junction, on the Cleveland, Cincinnati, Columbus, and St Louis Railway, in which twenty-one persons lost their lives and forty-seven were seriously injured, while the damage to freight and rolling stock was estimated at 1,000,000 dollars. It appears that while an express train was travelling at the rate of forty miles an hour, it ran into a siding, upon which a goods train, to which two oil-tank cars were attached, was standing. The tanks burst and the oil became ignited, and a series of explosions was produced from the vapour and air. The burning missiles were scattered in all directions, setting fire to the stockyard enclosure. Crowds of people rushed forward to try and prevent the flames from spreading to the stockyards, when a second terrific explosion occurred which shot fully 35,000 gallons of blazing oil up into the air, with terrible destructive effects.

While a dance was being held in the large room at a village inn in Deutch-Pereg, in February 1893, some children went into the cellar underneath—in which was stored a barrel of petroleum—with a lighted candle. The petroleum caught fire, and the vapour produced eventually exploded with terrific violence. Seventeen persons were killed, and twenty-two more or less seriously injured.

A very serious disaster occurred in Jersey City, U.S., which was caused by one of the large tanks owned by the Standard Oil Company being struck by lightning, and the contents being ignited; the tank burst with violence, and the blazing liquid was scattered in all directions, setting fire to other tanks. Eighteen tanks of crude oil and two of naphtha, each averaging 10,000 barrels, were destroyed.

POISONOUS GASES.

In a case where a woman and her two children were found dead in bed at Sunderland, the evidence produced at the inquest appeared to demonstrate that the flap of a register stove in the bedroom had fallen down, and that the slow combustion of the coal in the ill-ventilated room evolved noxious gases, the breathing of which caused asphyxia, and the death of the unfortunate family.

Two women of Tredegar retired to sleep one night in a room in which they had placed a bucket of live coals for warmth. The apartment, however, had no ventilation, and the poisonous gases emanating from the fire proved sufficient to cause the deaths of the two occupants of the room.

During service one Sunday morning at the Parish Church of Hucclecote, near Gloucester, a girl screamed and fainted. A few minutes after her sister also fainted, and several ladies followed suit one by one. The church, it appeared, was heated by coke stoves, and ill ventilated, and the breathing of the products of combustion (carbonic oxide and carbonic acid, &c.) was responsible for the occurrence.

POTASSIUM NITRATE (Saltpetre Nitrate).

An explosion, which proved rather destructive to life and property, occurred in New York on the 19th July 1845, in which saltpetre was the acting agent and probable cause. It happened in the store of Messrs Crocker & Warren, seven floors in height, in which were stored 1,000,000 lbs. weight of merchandise, of which 347,207 lbs. were saltpetre contained in double gunny bags, each containing 180 lbs. in piles alternating with various combustible goods. The first indication of the disaster was a series of detonations, which gradually increased in intensity, and culminated in a tremendous explosion, which resulted in the complete wreckage of the premises and a number of neighbouring buildings ; 230 houses and stores, containing merchandise valued at 2,000,000 dollars, being destroyed. The whole of the space where the explosion and fire occurred was filled with a huge flame, and burning fragments of various material were hurled in all directions with volcanic energy, starting other fires. Some of the flaming missiles reached the Hudson River, a quarter of a mile off, and endangered the shipping there.

Some years ago, the ship "Virginia," containing a cargo of saltpetre and linseed, was blown up. The report of the captain stated:—"In about ten minutes from the time the fire was discovered the after-hatch blew off, and at the same time the fire forced itself through the ship's side on the starboard quarter, a short distance from the water-line. In about ten minutes from this time, the boats having been got out, the crew, feeling the deck rising, jumped into the sea, and succeeded in getting into the boats, cut the painters, and shoved off. Almost at the same time an awful explosion took place, the fire rising to the height of 200 feet from the main and after hatches, and, a few seconds afterwards, from the fore hatch. At the same time the main and mizen masts went by the board. Five minutes from this time the ship disappeared, with all her cargo. In twenty-five to thirty minutes from the time the fire was discovered no trace of the ship was visible."

The lesson to be learnt from these disastrous explosions is, that all substances such as nitre, chlorate of potash, sodium peroxide, &c., which contain a large percentage of available oxygen, should not be stored near or in contact with combustible bodies, especially if subjected to friction. For although not themselves explosive, they part with oxygen very readily if heated, or on friction with a combustible body. The danger is increased if they are in contact with baggage containing any oily matter, or other bodies liable to spontaneous combustion.

SHELL.

A sergeant-instructor of the 1st Lanark Artillery Volunteers, who was preparing for practice, was in the act of fixing a fuse into a 40-pounder shell by driving it with blows on the head, which contained a detonating arrangement, when the shell suddenly exploded, killing two officers and injuring six men.

THROW-DOWN CRACKERS.

Some years ago, what might have been a serious explosion occurred in a van at the Great Western Railway terminus at Paddington. It appears that a deal box, which had been consigned as "stationery," in reality contained throw-down crackers, which are compounded of grit and fulminate of silver twisted up tightly in pieces of paper. While the carman was removing the box from the van it exploded, and was shattered to atoms, throwing the man a considerable distance, and putting out all the gas in the place. The consignors were rightly prosecuted by the company, and convicted.

TURPENTINE.

A series of explosions, resulting in a serious fire, took place in Liverpool some years ago in a large *fireproof* warehouse containing hundreds of barrels of turpentine, large stocks of cotton goods, &c. It appears one of the men employed upon the premises, in snuffing a tallow candle with his fingers, threw the piece of fiery wick into the open bunghole of a sample barrel of turpentine. This started a fire, and the vapours of turpentine and air exploded and wrecked the premises.

PICRIC ACID.

A fatal accident occurred with this substance at the works of Messrs Henry Glover, Sons, & Co. Limited, in 1887. It appeared that some picric acid had been supplied to the firm, at the request of a former foreman, for use in colouring soap, and that when the foreman left on 12th March 1886 a small quantity remaining was placed in a barrel with some old sweepings. It remained there until the 24th August 1887, when the barrel was found amongst some lumber. In order to get rid of the refuse which the barrel contained, the smell of which had then become offensive, one of the men began to shovel it on to a boiler fire, when suddenly there was a slight explosion, which fired the remainder of the rubbish in the barrel. The man was severely burnt, and eventually died from the injuries received.

VARNISH.

Some Welsh flannel was stored in a warehouse in contact with leaky cans containing varnish. The flannel became soaked with the varnish, and owing to the rapid oxidation of the latter, consequent upon the large area exposed to the air, in the pores of the flannel, the heat given out was sufficient to cause ignition, and serious damage was done.

"SPONTANEOUS" COMBUSTION OF WOOD.

Under certain conditions there can be no doubt that wood —especially wood of a resinous nature, such as pitch pine—can be rendered inflammable without necessarily coming in actual contact with flame.

The narrator remembers an instance of the wooden lagging that encircles locomotive boilers being found charred, and to burst into flame on the outer covering of iron plates being removed. The temperature of the wood nearest the boiler would probably never get beyond 300° F., while the igniting point of the wood is from 600° to 800° F.; that temperature could only have been attained by oxidation, which of course is considerably enhanced by the wood being almost surrounded in a bath of hot air.

There are numerous instances on record where fires have originated through wood being in contact with high-pressure hot-water pipes, in which the temperature is much higher than 212° F.,—the boiling point of water at ordinary pressure,—although it is doubtful whether wood at a temperature of

212° F. would spontaneously ignite in air. Pine wood smokes at 250° F.

The cause of the ignition of wood and other combustible matter in contact with high-pressure steam-pipes is easily explained. Assume a high-pressure steam-pipe to be boxed in with wood. The wood soon becomes very dry, and the surface nearest the pipes gradually becomes parched, and carbonised through superficial destructive distillation. As time goes on, the inner surface becomes converted into a porous charcoal, and gets saturated more or less with oleaginous products brought about by the destructive distillation of the internal portions of the wood. Here then we have a superficial layer of porous charcoal containing oily matter in a bath of very hot air,—conditions which certainly appear highly conducive to spontaneous combustion.

A glass bottle of spherical shape, filled with distilled water, was placed upon a pine-wood table on a bright summer's day, and without any apparent cause the table was suddenly ablaze. Ignition it was found was caused by the sun's rays becoming concentrated upon the portion of the table upon which the bottle was standing, the bottle acting as a lens.

XYLONITE (Celluloid).

During the cementation of some sheet xylonite at the Homerton works of the British Xylonite Company, a fire took place, resulting in the death of a man and considerable structural damage.

Xylonite is produced from tissue paper, by treating it with sulphuric and nitric acids, and converting the resulting nitro-cellulose into a pulp which is afterwards mixed with camphor and spirits of wine, worked into a dough, pressed into blocks, and cut into sheets. The fire originated during the cementation of some sheets in a steam-jacketed iron press, which through some defect in the machinery allowed a portion of the hot xylonite to become exposed to the air. Inflammable vapours were quickly given off, and coming into contact with a lighted gas jet hard by caught fire, with a dull explosion. The premises were considerably damaged by fire, and a man lost his life, being overcome by the fumes. The quantity of xylonite upon the premises at the time of the disaster amounted to four or five cwt., all of which was consumed by the fire, and it is instructive to note that even this large quantity did not produce any further explosion, but burned rapidly away.

A singular accident with celluloid occurred in Paris some time ago. A little girl who wore a celluloid comb in her hair sat before the fire reading in a bending posture, her head facing the fire, when suddenly the comb took fire and severely burned her head. The burning point of celluloid is 180° F., and this temperature would soon be attained near a fire.

A terrible explosion occurred a few years ago at Arlington, New Jersey, in a factory where piano-keys, knife and umbrella handles were manufactured from celluloid. Three factory buildings were completely wrecked and set on fire, two persons were killed and many injured, and the damage done was estimated at over £10,000. The cause of the explosion was not definitely ascertained, but it no doubt arose from the ignition by a spark or flame of the inflammable vapour produced in manufacturing celluloid mixed with air.

Although celluloid, xylonite, and similar bodies made from nitro-cellulose and camphor, are not of an explosive nature at an "ordinary" temperature, they detonate when struck at a temperature of 160° to 180° F.; and in consideration of the low temperature at which ignition takes place, the rapid manner in which the material burns when once ignited, together with the dangerous materials used in its production, its manufacture should not be tolerated in any populous neighbourhood, but should be carried on in isolated districts only.

A Summary of the various causes of fires in the Metropolis for 1894, issued by the Fire Brigade Committee of the London County Council :—

Airing bedding	3
Airing linen	58
Bleaching jute	1
Boiler, explosion of	4
Boiler, overheat of	8
Boiling over fat, oil, pitch, tar, &c.	42
Bomb, explosion of	1
Burning rubbish	12
Candle	134
Candle, curtains or window blinds coming in contact with	23
Chemicals, explosion of	1
Chemicals, leaking	1
Children playing with fire	46
Children playing with lucifers	86
Coffee roasting	1
Concussion	2
Copper, defect in	1
Copper, overheat of	4
Electric wires, fusion of	1
Electric wires, overheat of	2
Fire, clothes coming in contact with	3
Fire, goods coming in contact with	1
Fire, spirit upsetting on	1
Fireworks, letting off	1
Flue blocked up	8
Flue, defect in	99
Flue, timber in	3
Flue, copper, defect in	4
Flue, furnace, defect in	5
Flue, furnace, overheat of	5
Flue, foul	14
Flue, overheat of	12
Flue, adjoining, defect in	29
Flue, adjoining, foul	8
Flue, adjoining, overheat of	6
Friction	1
Friction of machinery	3
Fumigating	5
Furnace, overheat of	7
Gas bracket, swinging	40
Gas, escape of	79
Gas, explosion of	13
Gasfitters at work	5
Gaslight	5
Gaslighting	14
Gaslight, curtains or window blinds coming in contact with	38
Gaslight, decorations coming in contact with	7
Gaslight, goods coming in contact with	20
Gaslight, overheat of	6
Gas, seeking for an escape of, with light	31
Gas stove	5
Gas stove, overheat of	15
Gas stove, portable	6
Hearth, defect in	4
Hearth, timber under	4
Hot ashes	88
Hot iron	1
Hot rivets	1
Intoxication	2
Kiln, overheat of	1
Lamp, mineral oil	26
Lamp, mineral oil, curtains or window blinds coming in contact with	20
Lamp, mineral oil, decorations coming in contact with	1
Lamp, mineral oil, exploding	90
Lamp, mineral oil, upset	337
Lamp, naphtha	2
Lamp, spirit, upset	1
Lighted taper	8
Light thrown down	276
Light thrown from street	22

Lime slaked by rain	8
Lime slaking	9
Lucifers	12
Mineral oil, upsetting	1
Oven, overheat of	7
Plumbers at work	8
Salvage, overheat of	2
Smokehole, overheat of	4
Smoking tobacco	14
Spark from copper fire	4
Spark from fire	179
Spark from flue	5
Spark from flue adjoining	7
Spark from forge	2
Spark from furnace	2
Spark from locomotive	1
Spontaneous ignition	4
Steam pipe, overheat of	1
Stove improperly set	21
Stove, overheat of	16
Stove adjoining, overheat of	1
Stove, drying goods, falling on	1
Stove drying, overheat of	15
Stove, mineral oil	14
Stove, mineral oil, exploding	9
Stove, mineral oil, overheat of	2
Stove, mineral oil, upset	9
Stove pipe, overheat of	3
Stove, portable	2
Stove, spirit, exploding	1
Vapour of spirit coming in contact with flame	12
Arson	1
Doubtful	5
Incendiarism	2
Unknown	863
	3,061

A LIST of the more important OUTRAGES and ATTEMPTS, and suspicious cases of DISCOVERIES of EXPLOSIVES (exclusive of scares), which have engaged the attention of Her Majesty's Inspectors of Explosives during the period 1881-1893 inclusive.

1881.

January 14.—An attempt to blow up the Barracks at Salford by dynamite. The injury to the Barracks was insignificant, but one boy was killed and another injured. (*See* Annual Report of H.M. Inspector of Explosives for 1881, page 46.)

March 16.—An attempt to injure the Mansion House, London, by a box containing from 15 to 20 lbs. of gunpowder. The touchpaper by which the gunpowder was to have been fired was extinguished by a policeman. (*Ibid.*, page 47.)

May 16.—An attempt to blow up the Police Barracks at Liverpool with gunpowder in iron piping. The damage to the building was inconsiderable, and no one was hurt. (*Ibid.*, page 48.)

June 10.—An attempt to blow up the Town Hall, Liverpool, by an infernal machine, probably filled with dynamite. A great number of windows were broken and some iron railings were destroyed, but no one was injured. The two perpetrators were captured. (*Ibid.*, page 47.)

June 14.—A piece of iron piping filled with gunpowder exploded against the Police Station at Loanhead, near Edinburgh. Some windows were broken, but no other damage was effected. (*Ibid.*, page 50.)

June 30. — An importation of six infernal machines at Liverpool from America in the "Malta," concealed in barrels of cement. They contained lignin dynamite, with a clockwork arrangement for firing it. (*Ibid.*, page 50.)

July 2.—An importation of four similar machines at Liverpool in the "Bavaria." (*Ibid.*, page 50.)

August 15.—A large sandboat moored in the Tay at Perth blown up with dynamite. The perpetrator was convicted and sentenced to twelve months' imprisonment. (*Ibid.*, page 47.)

September 8.—An attempt to produce an explosion at the Barracks, Castlebar. A canister containing gunpowder was thrown over the wall, close to the magazine. The lighted fuse which was attached fell out, and no harm was done. (*Ibid.*, page 47.)

1882.

February 18.—Boxes fitted up as infernal machines sent to various persons in Edinburgh by a man who was afterwards convicted of the offence and sentenced to twenty years' penal servitude. About eight persons were injured. (Annual Report for 1882, page 47.)

March 26.—An attempt to blow up Weston House, Galway, with dynamite in an iron pot enclosed in a sack. Five persons were afterwards convicted of the outrage. (Annual Report for 1883, page 49.)

March 27.—A 6-inch shell charged with explosive thrown into a house in Letterkenny. The explosion caused considerable damage.

April 2.—An attempt to destroy the Police Barracks in Limerick by firing some dynamite on the window sill. (Annual Report for 1882, page 47.)

May 12.—A discovery of a parcel containing 12 lbs. to 20 lbs. of gunpowder, with lighted touchpaper or fuse attached, at the Mansion House, London. (*Ibid.*, page 47.)

1883.

**January* 20.—An explosion of lignin dynamite at Tradeston Gasworks, Glasgow, doing considerable damage. (Annual Report for 1883, page 48; Special Report, No. L., dated 14th March 1883.)

**January* 21.—An explosion of lignin dynamite at Possil Bridge, Glasgow. Two or three persons passing sustained slight injury. (*Ibid.*)

**January* 21.—An explosion of lignin dynamite at Buchanan Street Station, Glasgow, in a disused goods shed. (*Ibid.*)

March 15.—An explosion at the Local Government Board Office, Whitehall, causing considerable local damage. (*Ibid.*, Special Report, No. LI., dated 27th April 1883.)

March 15.—An abortive explosion of lignin dynamite outside a window at the *Times* office. (*Ibid.*)

March 27.—Two infernal machines, containing 28 lbs. of lignin dynamite (probably home-made), discovered at Liverpool. (*Ibid.*, page 49.) Four persons were convicted and sentenced to penal servitude for life.

April.—The discovery of a factory of nitro-glycerine at Birmingham, and of a large amount of nitro-glycerine brought thence to London. (Annual Report for 1883, page 7.) The occupier of the house and others were subsequently convicted and sentenced to penal servitude for life.

October. — An explosion in the Metropolitan Railway, between Charing Cross and Westminster, unattended with personal or serious structural injury. (*Ibid.*, page 49; Special Report, No. LV., dated 17th November 1883.)

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* In connection with these three explosions, ten persons were subsequently convicted. (*See* Annual Report for 1885.)

October 30.—An explosion on the Metropolitan Railway, near Praed Street. Three carriages sustained serious injury, and about sixty-two persons were cut by the broken glass and débris, and otherwise injured. (*Ibid.*)

November 22.—Two infernal machines discovered in a house in Westminster, occupied by a German named Woolf. Two men were tried, and in the result the jury disagreed and a *nolle prosequi* was entered on behalf of the Crown. (*Ibid.*, page 50.)

1884.

January 16.—The discovery of some slabs of Atlas powder A. (American make) in Primrose Hill tunnel.

February 26.—An explosion in the cloak-room of the London, Brighton, and South Coast Railway at Victoria Station of Atlas powder A. (American make), left in a bag or portmanteau. (Annual Report for 1884, page 37; Special Report, No. LIX., dated 8th March 1884.)

February 27.—The discovery of a bag containing some Atlas powder A., with clockwork and detonators at Charing Cross Station. (*Ibid.*)

February 28.—A similar discovery at Paddington Station. (*Ibid.*)

March 1.—A similar discovery at Ludgate Hill Station. (*Ibid.*)

April 11.—A discovery of three metal bombs containing dynamite (probably American make) at Birkenhead, in possession of a man named Daly, who was afterwards sentenced to penal servitude for life. (*Ibid.*, page 38.)

May 30.—An explosion of dynamite at the Junior Carlton Club, St James's Square. About fourteen persons were injured. (*Ibid.*, page 38; Special Report, No. LXII., dated 10th June 1884.)

May 30.—An explosion of dynamite at the residence of Sir Watkin Williams Wynn, St James's Square. (*Ibid.*)

May 30.—An explosion of dynamite in a urinal under a room occupied by some of the detective staff in Scotland Yard. It brought down a portion of the building, besides severely injuring a policeman and some persons who were at an adjacent public-house. (*Ibid.*)

May 30.—A discovery of Atlas powder A., with fuse and detonators, in Trafalgar Square. (*Ibid.*)

November 28.—An attempted destruction of a house at Edenburn, near Tralee, occupied by Mr Hussey. The injury, which was doubtless accomplished with dynamite, was less serious than was intended, and no one sustained bodily harm. (*Ibid.*, Special Report, No. LXVIII., dated 5th December 1884.)

December 13.—An explosion of a large charge of dynamite or other nitro-compound under London Bridge, fortunately doing very little damage. (*Ibid.*)

1885.

January 2.—An explosion in the Gower Street tunnel of the Metropolitan Railway, caused by about 2 lbs. of some nitro-compound fired apparently by a percussion fuse. Damage inconsiderable.

**January* 24.—An explosion in the Tower of London, caused, beyond all reasonable doubt, by about 5 to 8 lbs. of Atlas powder A. (American make). Three or four persons were slightly injured, and considerable damage was done to the Armoury. (Annual Report for 1885, page 59.)

**January* 24.—An explosion of a similar amount of Atlas powder A. (American make) at Westminster Hall. Three persons were injured severely and others slightly, and very considerable damage was done to the Hall and surroundings. (*Ibid.*, page 59.)

**January* 24.—An explosion in the House of Commons (probably caused by a similar amount of the same explosive).

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* In connection with these three outrages, two men (Burton and Cunningham) were afterwards convicted and sentenced to penal servitude for life.

No persons were injured, but very considerable damage was done to the House of Parliament. (*Ibid.*, page 59.)

February 10.—A discovery of dynamite (of American make) in a house in Harrow Road, Paddington.

March 9.—A discovery of Atlas powder A. in the roof of a sawmill at Bootle.

April 23.—Explosion of an infernal machine containing gunpowder at the Admiralty, Whitehall. Mr Swainson, in whose room the explosion occurred, sustained severe injuries, and the room and neighbouring apartments were much damaged. (*Ibid.*, page 59.)

1886.

March 24.—Attempted injury, with blasting gelatine, to the house of Mr Tyzack, manager of the South Medomsley Colliery, Durham. (Annual Report for 1886, page 41.)

June 23.—An attempted injury, by explosion of dynamite, of new reservoir in connection with some new waterworks at Callington. (*Ibid.*)

July 12.—Bottles filled with gunpowder thrown among the crowd at an Orange demonstration at Derry. (*Ibid.*)

September 1.—Two attempts to injure residents by means of an iron pipe charged with powder and fused. (*Ibid.*)

1887.

January 27.—Injury to three shops at Dudley by malicious explosion of gunpowder. (Annual Report for 1887, page 45.)

January 1.—An explosion maliciously effected (by means probably of gun-cotton or dynamite) in the streets of Harlech. (*Ibid.*, page 46.)

February 17.—Attempted dynamite outrage at Paradise House, near Kildysart, County Clare, the residence of the Recorder of Galway. (*Ibid.*, page 45).

March 20.—Injury to a man at Walton, near Preston, by an infernal machine. (*Ibid.*, page 45.)

March 8.—Attempted injury by tonite to canal near Preston. (*Ibid.*, page 44.)

April 21.—Malicious explosion of gunpowder at house at Newcastle West, occupied by Mr John Murphy. (*Ibid.*, page 45.)

May 4, 21, and 24.—Three outrages with explosives at Hebburn, Durham. (*Ibid.*)

July 27.—Attempt to injure the Police Station at Llanerchymedd by means of gunpowder. (*Ibid.*)

August 16.—Attempt to injure railway bridge at Ennis with dynamite. (*Ibid.*)

October 23.—Malicious explosion at the house of County Inspector Ridge, Royal Irish Constabulary, at Cavan. (*Ibid.*, page 44.)

November 20. — Discovery of conspiracy between Callan and Harkins to commit an outrage or outrages by means of dynamite. (*Ibid.*, page 46.)

December 6.—Attempt to injure the residence of the High Sheriff of Kerry at Listowel. (*Ibid.*, page 45.)

December 16.—Explosion of an infernal machine on the premises of a person at Macroom who had offended the Land League. (*Ibid.*)

April 16.—Explosion of gunpowder on the premises of a Mr William Maddocks, contractor, Birkenhead, probably intended to cause alarm rather than real damage. (*Ibid.*)

August.—An outrage was perpetrated at Bodvain Rectory, Denbighshire, by exploding some substance against a window. (*Ibid.*, page 46.)

1888.

February 18 *and* 23, *September* 18, *and December* 6.—Five minor outrages or suspicious circumstances suggesting intended attempts at explosive outrages in Ireland—at Ennis, Listowel, Letterkenny, Coleraine, and Skibbereen. (Annual Report for 1888, page 44.)

April 29.—A small charge of gunpowder was exploded close to a new smallpox hospital, Trooper's Hill, St George, Gloucestershire. (*Ibid.*)

1889.

September 7.—Explosion of an infernal machine in Mr Smith-Barry's office, near Tipperary. (Annual Report for 1889, page 41.)

November 18.—Attempt by means of an infernal machine to blow up the police and bailiffs engaged in carrying out evictions on Lord Clanricarde's estate near Woodford, co. Galway. (*Ibid.*, page 40.)

November 28.—Attempt to explode infernal machine at Rochdale School Board Office. (*Ibid.*, page 41.)

1890.

January 27.—Explosion of infernal machine in main street of Macroom. (Annual Report for 1890, page 41.)

March 22.—Destruction of a hut at a railway crossing near Toome Station, Co. Antrim, by malicious explosion. (*Ibid.*)

July 17.—Attempt to do injury or to create alarm by means of an infernal machine at the Falmouth Custom House. (*Ibid.*)

September 25.—Explosion of a stone jar filled with gunpowder on window sill of a surgery occupied by Chairman of Town Commissioners, Tipperary. (*Ibid.*, page 42.)

October 9.—Attempted outrage by means of blasting powder on the premises of a baker at Templecombe. (*Ibid.*)

1891.

January 15.—Malicious injury by explosion to the Dawsholm Gasworks, near Glasgow. (Annual Report for 1891, page 40.)

July 3.—Personal outrage, by the explosion of a detonator, on a woman in the streets of Sunderland. (*Ibid.*)

October 25.—Injury to offices of *National Press* in Dublin by means of an explosive thrown into the building. (*Ibid.*)

November 5.—Malicious explosion of tonite in the house of a police constable, and other houses at Croscombe, Somerset. (*Ibid.*)

December 31.—Malicious explosion in the offices of the Chief Secretary, Dublin Castle. (*Ibid.*, page 39.)

December.—Discovery of a packet of dynamite, with fuse, in the Dublin Post Office. (*Ibid.*)

1892.

January 29.—Explosion of infernal machine at private residence near Bristol. (Annual Report for 1892, page 53.)

March 24.—Conviction of anarchists at Walsall for being in possession of explosives for unlawful purposes, under Explosive Substances Act, 1883. (*Ibid.*, page 53.)

April 5.—Explosion of infernal machine during Durham mining strike at house at Castle Eden Colliery. (*Ibid.*, page 53.)

June 5.—Explosion of dynamite or gelatine cartridge in doorway of house at Inverkeithing. (*Ibid.*, page 54.)

August 5. — Explosion of a quantity of gunpowder on window sill of an hotel at Rathkeale. (*Ibid.*, page 54.)

August 12.—Explosion of a quantity of gunpowder in a miner's house at Low Spennymoor. (*Ibid*, page 54.)

December 24.—Explosion of infernal machine outside the Detective Office in Exchange Court. One detective officer was killed. (*Ibid.*, page 53.)

1893.

April 19.—Discovery of a tin can containing about 10½ lbs. of gunpowder, with an arrangement for exploding it, on the line at the Newport end of the Gair Tunnel.

May 6.—Explosion of an infernal machine at the Four Courts, Dublin, situated on the north bank of the Liffey, at Inns Quay.

July 22.—Death of a man at Broadstairs from the explosion of an infernal machine which had been sent to him by post.

July 28.—Explosion of a detonator in a public-house at Great Bridge, causing serious injury to three men.

August 27.—A cartridge, probably of tonite, was thrown into the garden of a farmhouse at Euxton, causing damage to windows.

September 17.—The house of a colliery fireman at Parr was wrecked by the explosion of some explosive, probably roburite.

October 1.—Explosion, without injury, of some unknown substance during the service at St George's (Roman Catholic) Cathedral.

October 20.—Explosion of roburite on window sill of a house occupied by a colliery fireman at Broad Oak Road, Parr.

October 27.—Explosion of some substance placed on the window sill of a house occupied by a gamekeeper at Ovingham.

November 26.—Discovery of a tin box containing dynamite, with fuse attached, at Aldborough Barracks, Dublin.

December 10.—An explosion of a malicious character outside the dwelling-house of a gasman, in Cowie's Square, Craigneuk, Dalziel.

PART III.

SPECIAL RAILWAY CLASSIFICATION, MODE OF PACKING, AND GENERAL REGULATIONS FOR THE CONVEYANCE OF EXPLOSIVES AND OTHER DANGEROUS GOODS BY MERCHANDISE TRAINS.

No Explosives or other Dangerous Goods, except those provided for in this Special Classification with conditions of carriage, will under any circumstances be accepted for conveyance.

PART III.

RAILWAY REGULATIONS.

GENERAL.

1. The Company have publicly given notice that they are not common carriers of Explosives, and that they do not undertake the carriage of any Explosive, except on special conditions signed by the sender thereof, or by the person delivering the same to the Company for carriage.

2. Senders giving incorrect Consignment Notes or otherwise attempting to forward any Explosive or Dangerous Article under improper declaration or contrary to the following Regulations, will in every case be prosecuted by the Company to whom the article is tendered for carriage.

3. Dangerous Goods will only be carried by the Company at Owner's risk, and under the conditions set forth in the respective Consignment Notes contained in these Regulations, and further, as regards Explosives, in accordance with the Bye-Laws for regulating the carriage of Explosives, made in pursuance of the Explosives Act, 1875, as follows, viz. :—

"Bye-Laws made with the sanction of the Board of Trade for the regulation of the Loading, Unloading, and Conveyance of Explosives on the Railways of the..Railway Company, hereinafter called the Company, made under and in pursuance of the Explosives Act, 1875, 38 Vict. c. 17, and every other power and authority vested in the Company.

"(*a*.) The words and expressions used in the following Bye-Laws shall respectively have and include the several meanings assigned to them or defined in 'The Explosives Act, 1875,' and in the Order of Her Majesty in Council, dated the 5th of August 1875, made in pursuance of Section 106 of the said Act, unless the subject or context otherwise requires.

"(*b*.) The term 'Explosive' means and shall include and apply to every article and substance mentioned as, or defined to be, an Explosive in and by the 3rd Section of the said Act, or the said Order in Council, or any Order in Council which may hereafter be made in pursuance of the said Act.

"(*c.*) Where, by any of these Bye-Laws, any time is prescribed or allowed for giving any notice to the Company, or for the doing of any act by the Company, such time shall be computed exclusively of Sunday, Christmas Day, Good Friday, and any statutory Bank Holiday.

"1. No carriage containing any Explosive which the Company shall, by any notice or regulation for the time being in force, notify that they will not receive, forward, or carry, shall be delivered to the Company for conveyance, or be brought, sent, or forwarded to or upon any Railway of the Company.

"2. No person shall send to the Company any consignment of Explosive, unless he has given to the Company forty-eight hours' previous notice in writing of his intention to send such consignment, and stating the true name, description, and quantity of the Explosive proposed to be conveyed, and his own name and address, and also the name and address of the proposed consignee, and has had an intimation in writing from the Company that they are prepared to receive such consignment.

"3. Consignments of Explosive shall be sent to the Company's forwarding station, and shall be received by their servants, only at such times during the hours of daylight, that is to say, between sunrise and sunset, as the Company may appoint; and every consignment and package containing any Explosive proposed to be conveyed on any railway of the Company shall immediately on the arrival thereof at the Company's station, wharf, or railway, be delivered to and received by the Company's servants authorised to receive dangerous goods, and by no other person whatsoever.

"4. No Explosive shall be loaded or unloaded on the Company's premises by the consignor or consignee thereof or their servants, except between sunrise and sunset.

"5. Safety cartridges and percussion caps and safety-fuse (for blasting) may be conveyed by passenger train, provided all due precautions be taken by the sender for the prevention of accident by fire or explosion; also railway fog signals for the Company's own use; but, except as aforesaid, no Explosive whatever shall be conveyed by passenger train.

"6. Gunpowder, or any Explosive made with gunpowder, included in the 2nd Division of the 6th (Ammunition) Class of Explosives, as classified by the said Order in Council of the 5th of August 1875, if packed in metallic cylinders of a pattern approved by the Company, and similar in construction and security to those used by Government for the conveyance of small quantities of gunpowder by railway,* may be conveyed along with ordinary goods traffic in a carriage not containing any article or substance liable to cause or communicate fire or explosion.

"7. No Explosive of the 5th (Fulminate) Class, nor any Explosive of the 6th (Ammunition) Class, containing its own means of ignition, nor any Explosive of the 7th (Firework) Class, shall be conveyed in the same carriage with any Explosive not of the class and division to which it belongs, unless it be sufficiently separated therefrom to prevent any fire or explosion which may take place in one such Explosive being communicated to another.

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* For descriptions of the Government metallic cylinders, *see* page 334.

"8. There shall not be conveyed in the same carriage with any Explosive any Lucifer Matches, Fusees, Pipe-lights, Acids, Naphtha, Paraffin, Petroleum to which the Petroleum Act, 1871, or any Act repealing or amending the same, applies, or any other volatile spirit or substance liable to give off an inflammable vapour at a temperature below 100° Fahrenheit,* or liable to spontaneous ignition, or to cause or communicate fire or explosion.

"9. On each side of every carriage containing any Explosive there shall be affixed in conspicuous characters, by means of a securely attached label or otherwise, the word 'Explosive,' or the name of the Explosive with the word 'Explosive,' except when containing gunpowder or ammunition packed in metallic cylinders as provided for in the 6th of these Bye-laws; and every carriage containing Explosive shall be placed as far as practicable from the engine attached to the train.

"10. Not more than five carriages containing Explosive shall be loaded or unloaded at or on any railway station or wharf of the Company, or be attached to or conveyed by any one train at any one time; and the quantity of Explosive to be contained or loaded in any one such carriage at any one time shall not exceed 10,000 lbs. in weight, provided always that the quantity of Explosive to be contained or loaded in any one such carriage shall not exceed one ton in weight, unless the carriage shall be a covered van.

"11. If the Explosive to be conveyed is not effectually protected from accident by fire from without, by being placed in the interior of a carriage which is enclosed on all sides with wood or metal, then the Explosive shall be completely covered with painted cloth, tarpaulin, or other suitable material so as to effectually protect it against communication of fire.

"12. There shall not be any iron or steel in the interior of the portion of the carriage where the Explosive is deposited, unless the same be covered either permanently or temporarily with leather, wood, cloth, sheet-lead, or other suitable material.

"13. When the stowing of Explosive in any carriage, or the loading or unloading of any Explosive, is undertaken by any person other than the Company, all due precautions shall be taken by such person by careful stowing and loading and unloading and otherwise, to prevent and secure such Explosive from being brought into contact with, or endangered by, any other article or substance liable to cause fire or explosion.

"14. In loading or unloading any Explosive, the casks and packages containing the same shall, as far as practicable, be passed from hand to hand, and not rolled upon the ground, and in no case shall any such casks or packages be rolled unless hides, cloths, or sheets have been previously laid down on the platform or ground over which the same are to be rolled. Casks or packages containing Explosive shall not be thrown or dropped down, but shall be carefully deposited and stowed.

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* NOTE.—By the Petroleum Act, 1879, the limit of 100° was altered to 73° Fahrenheit, under the test set forth in Schedule One to that Act. (For description of test, *see* page 77.)

"15. No person while employed in loading, stowing in any carriage, or unloading any Explosive included in Classes 1, 2, 3, 4, or 5 of the classification of Explosives, as classified by the said Order in Council, dated 5th August 1875, shall wear boots or shoes with steel or iron nails, steel or iron heels, or tips of any kind, or have about his person any lucifer match, explosive, or means of striking a light; and all persons employed in the loading, stowing, or unloading of any Explosive shall, while such loading, stowing, or unloading are going on, abstain from smoking.

"16. While the loading, unloading, or conveyance of Explosive is going on, all persons engaged in such loading, unloading, or conveyance shall observe all due precautions for the prevention of accidents by fire or explosion, and for preventing unauthorised persons having access to the Explosive so being loaded, unloaded, or conveyed, and shall abstain from any act whatever which tends to cause fire or explosion, and is not reasonably necessary for the purpose of loading, unloading, or conveyance of such Explosive, or of any other article carried therewith, and for preventing any other person from committing any such act; and such other person who, after being warned, commits any such act, shall be deemed to commit a breach of these Bye-Laws.

"17. The loading or unloading of Explosive into or out of any carriage, when once begun, shall be proceeded with with all due diligence until the same is completed.

"18. Packages containing any Explosive must be removed by the consignee from the station, wharf, or depôt of the Company to which they have been conveyed as soon as practicable, and with all due diligence after arrival; and if not removed within twelve hours after arrival the packages and contents may be forthwith sold by the Company, or otherwise disposed of as they think fit; and such packages shall in the meantime, and until such removal, sale, or disposal, be completely covered over with painted cloth, tarpaulin, or other suitable material.

"19. The Company may refuse to receive, forward, carry, or allow to be brought, or carried upon their railway, any carriage or package which they suspect to be packed or sent, or to contain any article or thing packed or sent, in contravention of the said Act, or of any of these Bye-Laws, or not in accordance therewith; and in case any carriage or package which the Company suspect to be so packed or sent, or to contain any such article or thing as aforesaid, shall be upon any railway of the Company, the Company may open, or require such carriage or package to be opened, to ascertain the fact.

"20. These Bye-Laws are supplemental to the Explosives Act, 1875; and in the event of any breach (by any act or default) of any of them, or any attempt to commit such breach, the following penalties and consequences will be incurred and ensue, that is to say:—

"(1.) The Explosive in respect of which, or being in the carriage, or train of carriages, in respect of which, the offence is committed, may, unless the offence be committed by the Company, be forfeited to the Company.

"(2.) The person committing the offence shall be liable to a penalty not exceeding £20 for each offence, and to a further penalty of £10 for each day during which the offence continues; and the owner of the carriage, or train of carriages, in respect of which, or containing the Explosives in respect of which, the offence is committed, the person in charge of such carriage, and the owner of such Explosive, shall each be liable to a similar penalty, if he was a party or contributed to such offence, or neglected to supply the proper means, or to issue proper orders for the observance, or has not used due diligence to enforce the observance of these Bye-Laws.

"21. Copies of these Bye-Laws shall be exhibited in a conspicuous place at the Stations on the Company's Railways, and may be obtained on application to the Secretary of the Company.

"22. The above Bye-Laws (with the exception of Bye-Law No. 5) do not apply to small packages of percussion caps, safety cartridges, or gunpowder, carried by passengers for private use and not for sale, not exceeding in the whole for one passenger at any one time 5,000 percussion caps and 1,000 safety cartridges in number, and 3 lbs. in weight of gunpowder, provided such gunpowder is contained in a substantial case, bag, canister, or other receptacle made and closed so as to prevent the gunpowder from escaping.

"NOTICE.

"The Company hereby give notice that they are not common carriers of Explosives, and do not undertake the carriage of any Explosive except on special conditions signed by the sender thereof, or by the person delivering the same to the Company for carriage."

TABLE OF PACKING AND CHARGES FOR AND SUPPLEMENTARY CONDITIONS OF CARRIAGE OF EXPLOSIVES AND OTHER DANGEROUS GOODS.

(*For the Government Classification of Explosives, see* 132.)

Description.	Charges. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
EXPLOSIVES. **Class I.** Gunpowder	In kegs, barrels, or in cardboard boxes packed in cases or kegs	5 & 50°/₀	Station to Station	*10/	1. Must in all cases be packed in kegs, barrels, cases, or metallic cylinders of the following qualities, viz.:— Kegs or barrels, in quarter, half, and whole barrel sizes. — Thickness according to size of barrel and quality of wood used; min. ½ inch.
	In canisters packed in cases or kegs	5 & 20°/₀	Station to Station	*10/	Canisters made of tin, copper, zinc, or other approved metal, and cardboard boxes sufficiently strong and well made to prevent leakage, enclosed in wooden cases or kegs. — Thickness of cases ½ inch, except the ends, which must be 1 inch.
	In metallic cylinders	3	Station to Station	3/6	Metallic cylinders - Of an approved pattern, and similar in construction and security to those used by the Government for conveyance of small quantities of Powder by rail.
	* When a Gunpowder van is specially required for any particular lot sent to a place beyond the line of the Company working the van from the sending station, the minimum charge is to be as for 10 cwts. per van, subject, however, to special arrangements between the Companies.				2. Each package before delivery to the Company must be labelled or branded in accordance with regulation No. 5, with letters of not less than 1 inch in depth, and addressed in such a manner as will enable speedy delivery to be effected. 3. No package must contain more than 100 lbs. weight of Gunpowder, and no truck be loaded with more than 4 tons 9 cwts. 1 quarter and 4 lbs. (10,000 lbs.) 4. Except when in metallic cylinders, the traffic must only be conveyed in a Gunpowder Van. When in metallic cylinders it may be conveyed along with ordinary goods, so long as the vehicle does not contain any article or substance liable to cause or communicate fire or explosion.
Class II. Nitrate Mixtures— Fortis Explosive - Safety Blasting Powder Westfalite -	Same as Gunpowder above.				Same as Gunpowder above.

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

<table>
<tr><th rowspan="2">DESCRIPTION.</th><th colspan="4">CHARGES.
The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.</th><th rowspan="2">Conditions of Carriage Supplementary to General Regulations.</th></tr>
<tr><th></th><th>Class.</th><th>Condition.</th><th>Min. Charge.</th></tr>
<tr><td rowspan="3">Class III.
NITRO-COMPOUNDS—
<i>Division</i> 1.
Amberite, No. 1 - -
Ballistite - - -
Blasting Gelatine No. 1
Blasting Gelatine No. 2
Carbonite - - -
Gelignite - - -
Matagnite Gelatine -
Oarite - - - -
Stonite - - -</td><td>In kegs, barrels, or in cardboard boxes packed in cases or kegs</td><td>5 & 50 °/o</td><td>Station to Station</td><td>*10/</td><td rowspan="3">1. Must in all cases be packed in kegs, barrels, or cases, of the following qualities, viz. :—
Kegs or barrels in quarter, half, and whole barrel sizes. } Thickness according to size of barrel and quality of wood used; min. ½ in.
Canisters, <i>when so packed with the consent of a Government Inspector</i>, made of tin, copper, zinc, or other approved metal, and cardboard boxes sufficiently strong and well made to prevent leakage, enclosed in wooden cases or kegs. } Thickness of cases ½ in., except the ends, which must be 1 in.
2. Each package before delivery to the Company must be labelled or branded in accordance with regulation No. 5, with letters of not less than 1 inch in depth, and addressed in such a manner as will enable speedy delivery to be effected.
3. No package must contain more than 50 lbs. weight of Explosive, and no truck be loaded with more than 4 tons 9 cwts. 1 qr. and 4 lbs. (10,000 lbs.).
4. The traffic must only be conveyed in a Gunpowder van.</td></tr>
<tr><td>In canisters, <i>when so packed with the consent of Government Inspector</i>, packed in cases or kegs</td><td>5 & 20 °/o</td><td>Station to Station</td><td>*10/</td></tr>
<tr><td colspan="4">* When a Gunpowder van is specially required for any particular lot sent to a place beyond the line of the Company working the van from the sending station, the minimum charge is to be as for 10 cwts. per van, subject, however, to special arrangements between the Companies.</td></tr>
<tr><td><i>Division</i> 2.
Amberite No. 2 - -
Bellite - - - -
E. C. Sporting Powder
Fortisine - - -
Gathurst Powder - -
Picric Acid - - -
Roburite - - -
Schultz's Powder - -
Securite - - -
Smokeless Powder -
Tonite - - - -
Walsrode Powder -</td><td colspan="4">Same as Gunpowder.</td><td>Same as Gunpowder.</td></tr>
</table>

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class IV.					
CHLORATE MIXTURES -	...	...	...	...	Not carried by any Railway Company.
Class V.					
FULMINATES - - -	...	...	...	...	Not carried by any Railway Company.
Class VI.					
AMMUNITION—					
Division 1. Railway Fog Signals -	In lots of 1 ton and upwards	4	Station to Station.	...	Must be packed in a box, barrel, or case of wood, metal, or other solid material, and of such strength, construction, and character, that it will not be broken or accidentally opened, or become defective or insecure whilst being conveyed, and will not allow any explosive to escape. Each package before delivery to the Company must be labelled or branded in accordance with Regulation No. 5.
	In lots under 1 ton	5	Station to Station.	5/	
	The charge for quantities under 1 ton at 5th class rate not to exceed as for 1 ton at 4th class rate				
Safety Small-arm Cartridges, *i.e.*, Cartridges not intended to be consumed in the chamber of the gun on firing	...	3	Collected and delivered	2/6	

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class VI.					
AMMUNITION—					
Division 2.					
Ammonite Cartridges for blasting, not containing their own means of ignition	...	Same as Gunpowder			Same as Gunpowder.
Gunpowder Blasting Cartridges not containing their own means of ignition	In kegs or barrels -	5 & 50 °/。	Station to Station.	*10/	Same as Gunpowder.
Patent Cotton Gunpowder Cartridges not containing their own means of ignition	...	Same as Gunpowder			Same as Gunpowder.
Securely Plugged Shells, filled with Gunpowder, not containing their own means of ignition	...	Same as Gunpowder			In Gunpowder vans only. Regulations provided for Gunpowder to apply.

* When a Gunpowder van is specially required for any particular lot sent to a place beyond the line of the Company working the van from the sending station, the minimum charge is to be as for 10 cwts. per van, subject, however, to special arrangements between the Companies.

Table of Packing and Charges, &c.—*Continued.*

Description.	Charges. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class VI.					
Ammunition—					
Division 3.					
Detonators for exploding high explosives (such as gun-cotton, dynamite, roburite, &c.)	...	Same as Gunpowder			1. These articles must be packed in a double package. The inner package must be a substantial case, bag, canister, or other covering, made and closed so as to prevent any Explosive from escaping, and must not contain more than 2 lbs. of such Explosive. 2. The outer package must be a box, barrel, or case of wood, metal, or other solid material, and must be of such strength, construction, and character that it will not be broken or accidentally opened, or become defective or insecure whilst being conveyed, and will not allow any Explosive to escape. 3. Any one such outer package must not contain more than 50 lbs. of such Explosive. 4. Each package before delivery to the Company must be labelled or branded in accordance with Regulation No. 5, with letters of not less than 1 inch in depth, and addressed in such a manner as will enable speedy delivery to be effected. 5. Except when in metallic cylinders, these articles must only be conveyed in a Gunpowder van. When in metallic cylinders they may be conveyed along with ordinary goods, so long as the vehicle does not contain any article or substance liable to cause or communicate fire or explosion.
Electric Blasting Fuses not containing their own means of ignition					
Fuses for Shell - -					
Metallic Fuses for projectiles for quick-firing guns, containing their own means of ignition					
Non-safety Small-arm Cartridges, *i.e.*, Cartridges intended to be consumed in the chamber of the gun on firing					

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class VII. FIREWORKS— *Division* 1. Firework Composition -	...	5 & 50 °/o	Station to Station.	*10/	1. Must be contained in a double package. The inner package must be a substantial canister, case, or other receptacle, hermetically sealed, and containing no more than 1 lb. of explosive. 2. The outer package must be a box, barrel, or case of wood, metal, or other solid material, and must be of such strength, construction, and character, that it will not be broken or accidentally opened, or become defective or insecure whilst being conveyed, and will not allow any Explosive to escape. 3. Any one outer package must not contain more than 20 lbs., and there must not be any iron or steel in the construction of any such inner or outer package, unless the same is effectually covered with tin, zinc, or other material. 4. To be carried in Gunpowder vans only. 5. Each package before delivery to the Company must be labelled or branded in accordance with Regulation No. 5, with letters of not less than 1 in. in depth, and addressed in such a manner as will enable speedy delivery to be effected.
Division 2. Amorces or Detonating Caps for Toy Pistol - Throwdowns - -	...	Same as Gunpowder			As Non-safety Cartridges.
Large Fireworks, such as Shells, Maroons, and Rockets	...	5 & 50 °/o	Station to Station.	*10/	1. Must be packed in a box, barrel, or case of wood, metal, or other solid material, of such strength, construction, and character, that it will not become defective or insecure whilst being conveyed, and will not allow any Explosive to escape. 2. The amount of Explosive in any one package must not exceed 100 lbs. 3. To be carried in Gunpowder vans only. 4. Each package before delivery to the Company must be labelled or branded in accordance with Regulation No. 5, with letters of not less than 1 in. in depth, and addressed in such a manner as will enable speedy delivery to be effected.

* When a Gunpowder van is specially required for any particular lot sent to a place beyond the line of the Company working the van from the sending station, the minimum charge is to be as for 10 cwts. per van, subject, however, to special arrangements between the Companies.

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.	Class.	Condition.	Min. Charge.	Conditions of Carriage Supplementary to General Regulations.
Class VII. FIREWORKS— *Division 2.*					
Manufactured Fireworks other than those previously described	In lots of 1 ton and upwards	4	Station to Station.	...	
	In lots under 1 ton	5	Station to Station.	5/	1. Must be packed in a box, barrel, or case of wood, metal, or other solid material, of such strength, construction, and character, that it will not become defective or insecure whilst being conveyed, and will not allow any Explosive to escape.
	The charge for quantities under 1 ton at 5th class rate not to exceed the charge as for 1 ton at 4th class rate.				2. The amount of Explosive in any one package must not exceed 100 lbs.
	Mixed packages of Fireworks containing any of the dangerous kinds previously named are to be charged at the higher rate.				3. Each package before delivery to the Company must be labelled or branded in accordance with Regulation No. 5, with letters of not less than 1 inch in depth, and addressed in such a manner as will enable speedy delivery to be effected.
Storm Signals and Storm Lights	In hermetically sealed tin - lined wooden cases	4	C. & D.	as for 1 ton	

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
INFLAMMABLE LIQUIDS. **Class A.** (*Vapour Inflammable at less than 73° Fahr., as per test set out at pages* 77-81.)					
Acetone - - - - Benzoline - - - Carburine - - - Enamel Anti-fouling Composition - - - Naphtha - - - - Petroleum - - - Rubber Solution & all other Solutions partly composed of Naphtha or other highly inflammable liquids - Toluol - - - - Wood Naphtha or Wood Spirit - - - -	In casks, iron drums, or iron cans, strongly made & securely closed so as to prevent all possibility of leakage	3	Station to Station.	1 ton	1. Each package before delivery to the Company must have a label attached, printed in conspicuous characters, bearing the words "Highly Inflammable," and stating the contents, and name and address of sender. 2. Loading and unloading must be performed during daylight.
	In hermetically sealed tins or bottles packed in sawdust in cases	5	Station to Station.	5/	3. Consignments for conveyance will not be accepted on a Saturday. 4. The Carriage must be prepaid in all cases.
Hydro-carbon from Oil Gas Manufacture	In iron drums, strongly made and securely closed so as to prevent all possibility of leakage	3	Station to Station.	1 ton	5. The traffic must not be stored in any of the Railway Company's enclosed sheds or warehouses.
Benzine Collas - Collodion - -	In hermetically sealed tins or bottles packed in sawdust in cases not exceeding 56 lbs. each package	5	Station to Station.	5/	
Ether - - - -	Do.	3	Collected and delivered	5/	

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class A—*continued.* Ether	In approved iron drums, hermetically sealed (*for Specification see below*)	3	Station to Station.	As for 1 ton	1. Each package before delivery to the Company must have a label attached, printed in conspicuous characters, bearing the words "Highly Inflammable," and stating the contents, and name and address of sender. 2. Loading and unloading must be performed during daylight. 3. Consignments for conveyance will not be accepted on a Saturday. 4. The carriage must be prepaid in all cases. 5. The traffic must not be stored in any of the Railway Company's enclosed sheds or warehouses.
Gasoline	In hermetically sealed tins or bottles	3	"	"	
	packed in cases not exceeding 84 lbs. each package	5	"	5/	
Do.	In approved iron drums, hermetically sealed (*for Specification see below*)	3	"	As for 1 ton	
Pentane	In hermetically sealed tins or bottles	3	"	"	
	packed in sawdust in cases not exceeding 84 lbs. each package	5	"	5/	

SPECIFICATION OF IRON DRUM FOR THE CARRIAGE OF ETHER AND GASOLINE, CONTENTS OF WHICH SHALL NOT EXCEED TEN GALLONS.

1. The drum is to be not more than 13½ inches diameter, and is to be made of tinned sheet iron (No. 18 B.W.G.), with a sunk longitudinal grooved joint well filled with solder. The top and bottom are to be hammered into a concave form, and flanged at the edges; they are to be let into the body of the drum 1½ inches, with the convex side outwards and the flange inwards, strongly fastened with solder, and afterwards well floated with solder all round. The drum is to be strengthened by three bands of iron (the ends of which are welded or riveted together) 2½ inches wide and ¼ inch thick, one round each end and one round the centre, each band to be firmly secured to the drum by solder. A brass screwed collar and plug, 1½ inches diameter, with sunk keyhole, is to be let into the top of the drum, and secured by a washer soldered round the collar inside. Painted drums must be white.
2. Each drum, when new, must be tested by hydraulic pressure of 40 lbs. per square inch, without showing signs of injury or leakage, also whenever it shows signs of damage or deterioration, and the test must be repeated at least once every year.
3. When filling the drum, an air space equal to at least 1-10th the capacity of the drum must be left. After filling, and before being handed to the Railway Company for conveyance, the senders must test each drum by a flame to ensure that there is no evaporation or leakage.
4. The screw plug of each empty drum must be securely fastened to its place before the empty drum is returned.
5. Damaged drums will not be accepted for conveyance.

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
INFLAMMABLE LIQUIDS. Bisulphide of Carbon -	In steel or wrought-iron drums— In lots under 2 tons The maximum charge for such lots not to exceed the charge for 2 tons at the mileage rate, for which see below.	Double 4th	Station to Station.	5/ per consignment.	1. The traffic is not generally carried by the Companies; and for those Companies who will not accept it for conveyance. 2. This article must be carried only in steel or wrought-iron drums. 3. Each drum tendered for conveyance must be securely placed in wooden cradles in three sections, and protected at each end by wooden bars to prevent concussion during transit. 4. The maximum gross weight of each drum must not exceed 5 cwts. 5. The drums must be made of wrought-iron or steel of a thickness not less than ¼ of an inch for drums up to 15 inches diameter. For drums of larger diameter the thickness must increase in proportion, so as to allow the usual margin of safety. 6. The drums must be tested by senders by hydraulic pressure of not less than 75 lbs. to the square inch when new, and also whenever they show signs of damage or deterioration afterwards, the test being repeated at least once every year. After filling, and before being handed to the Railway Companies for conveyance, the drums must be tested by sender to ensure that there is no evaporation or leakage.
	In lots of 2 tons and upwards—*	Per ton.			
	1 to 24 ml. inclusive	6d. per ml.	Station to Station.	5/ per ton.	
	25 ″ 36 ″	12/	″		
	37 ″ 50 ″	4d. per ml.	″		
	51 ″ 66 ″	16/8	″		
	67 ″ 80 ″	3d. per ml.	″		
	81 ″ 96 ″	20/	″		
	97 and upwards -	2½d. p. ml.	″		

7. The drums must be whitened from time to time as necessary with a mixture of whitening and oil.
8. The screw plugs by which the drums are closed must be made of brass with shoulders, and be fitted with washers made of lead.
9. The screw plugs to be securely fastened in their places before the empty drums are returned.
10. When filling the drums the sender shall leave an air space equal to 1-20th of the capacity of each drum, so as to allow room for expansion of the liquid consequent upon changes of temperature.
11. Each package before delivery to the Company must have a label attached, printed in conspicuous characters, bearing the words "Highly Inflammable," and stating the contents, and name and address of sender.
12. Loading and unloading must be performed during daylight.
13. Consignments for conveyance will not be accepted on a Saturday.
14. The carriage must be prepaid in all cases.
15. The traffic must not be stored in any of the Railway Company's enclosed sheds or warehouses.

* In the case of traffic to London charged according to this Mileage Scale, the charges are applicable only to the Stations of the Company carrying the traffic into London, and not beyond to any other London Station.

TABLE OF PACKING AND CHARGES, &C.—*Continued.*

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
Class B. (*Vapour Inflammable between 73° and 150° Fahr., as per test set out at pages* 77-81.)					
Paraffin Oil and Petroleum Oil	As per General Railway Classification	...	...	...	1. Each package before delivery to the Company must have a label attached, printed in conspicuous characters, bearing the word "Inflammable," and stating the contents, and name and address of sender. 2. The traffic must not be stored in any of the Railway Company's enclosed sheds or warehouses.
Naphtha - Wood Naphtha or Wood Spirit -	In tins -	4	Collected and delivered	...	
	In cases -	3		...	
	In casks or iron drums	2		...	
	In Owner's tank waggons, minimum charge as for 5 tons	2	Station to Station.	...	
Turpentine, Spirits of -	As per General Railway Classification	...	...	...	
Turpentine Substitutes -	Same as Turpentine, Spirits of	...	...	...	
Terebine or Sun Dryers Turpentine Varnish	Same as Varnish as per General Railway Classification	...	...	...	
Methylated Spirit - Spirit of Wine - Spirit Varnish -	In casks, cases, cans, or iron drums	3	Collected and delivered	...	
	In hampers -	4		...	
	Otherwise packed -	5		...	

NOTE.—Jars and glass or earthenware bottles only to be carried when protected by basket-work, and none exceeding 7 gallons in measure to be accepted for conveyance.

DESCRIPTION.	PACKING.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.
DANGEROUS OR CORROSIVE CHEMICALS. *Section* I.		
Ammonia Liquid, Fortissim (*also see below*) - - Bromine - - - -	In glass carboys, or in bottles packed in cases or hampers	In lots under 2 tons, double 4th Class, Station to Station, minimum charge, 5s. per consignment. The maximum charge for such lots not to exceed the charge for 2 tons at the mileage rates. In lots of 2 tons and upwards*— Minimum, 5s. per ton. Station to Station. 1 to 24 miles inclusive, 0s. 6d. per ton, per mile. 25 ,, 36 ,, 12 0 ,, 37 ,, 50 ,, 0 4 ,, per mile. 51 ,, 66 ,, 16 8 ,, 67 ,, 80 ,, 0 3 ,, per mile. 81 ,, 96 ,, 20 0 ,, 97 and upwards, 0 2½ ,, per mile. * In the case of traffic to London charged according to this Mileage Scale, the charges are applicable only to the Stations of the Company carrying the traffic into London, and not beyond to any other London Station.
Fluoric Acid - - -	In guttapercha bottles	
Hydrochloric Acid or Muriatic Acid, or Spirit of Salt (*also see page* 308) - Oil of Vitriol or Sulphuric Acid (*also see below and page* 308) - - -	In glass carboys, or in bottles packed in cases or hampers	
Oil of Vitriol or Sulphuric Acid	Packed in lead cisterns hermetically sealed, and enclosed in wooden cases containing not more than 1 cwt. of Acid	
Nitric Acid or Aquafortis (*also see below*)	In glass carboys, or in bottles packed in cases or boxes, or in stoneware jars, protected by wicker-work.	
Potassium - - - Sodium - - - - Sulphuric Anhydride or Sulphuric Acid Crystals	In iron drums hermetically sealed	

The above-named articles must not be loaded with other goods liable to be damaged thereby, and the services of loading and unloading must be performed by the owners, and not by the servants of the Company.—Nitric Acid and Sulphuric Acid must not be enclosed in the same package or loaded with other chemicals, nor must they be packed together, and bottles containing Nitric Acid must be packed in sand or other material on which the Acid has no chemical action.—Ammonia Liquid must not be enclosed in the same package or loaded with Acids or with Bromine.

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

DESCRIPTION.	PACKING.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.
Section 1—*continued.*		
Peroxide of Sodium - -	In hermetically sealed tins, each not exceeding 14 lbs. in weight, packed in strongly bound wooden cases, all of sufficient strength to prevent either the escape of the Peroxide of Sodium from the package, or the admission of moisture to the Peroxide of Sodium. The contents of any one package not to exceed 112 lbs. in weight.	
Hydrochloric Acid or Muriatic Acid, or Spirit of Salt	In bottles packed in sawdust in cases - -	To be charged at Class 5 rates, Collected and Delivered.
Hydrochloric Acid or Muriatic Acid, or Spirit of Salt (*also see page* 307) - Oil of Vitriol or Sulphuric Acid (*also see below and page* 307) - - -	In carboys - - - - - - -	In 4-ton loads. To be charged at Class C rates.
Oil of Vitriol or Sulphuric Acid, *exclusive of labour, Owner's risk* - -	In loose tanks, in Company's waggons—To be charged the gross weight, including the tank. Empty tanks to be charged at the Returned Empty rate - - - - - - In loose tanks, in Owner's waggons—To be charged the gross weight, including the tank In Owner's tank waggons—Tank waggons to be conveyed free both ways - - -	To be charged at Class C rates.

The above-named articles must not be loaded with other goods liable to be damaged thereby, and the services of loading and unloading must be performed by the owners, and not by the servants of the Company.—Nitric Acid and Sulphuric Acid must not be enclosed in the same package or loaded with other chemicals, nor must they be packed together, and bottles containing Nitric Acid must be packed in sand or other material on which the Acid has no chemical action.—Ammonia Liquid must not be enclosed in the same package or loaded with Acids or with Bromine.

TABLE OF PACKING AND CHARGES, &c.—*Continued.*

DESCRIPTION.	PACKING.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.
Section 1—*continued.*		
Amorphous Phosphorus -	In iron drums hermetically sealed - - -	To be charged at Class 4 rates, Collected and Delivered.
Phosphorus - - -	In iron drums hermetically sealed - - -	
Phosphorus - - -	In tins of sufficient strength, hermetically sealed, and properly packed in sawdust in wooden cases - - - - - -	
Section 2.		
Bleaching Liquids, Corrosive	In glass carboys, or in bottles packed in cases or hampers	In lots under 2 tons, double 4th Class, Station to Station, minimum charge 5s. per consignment. The maximum charge for such lots not to exceed the charge for 2 tons at the mileage rates. In lots of 2 tons and upwards*— Minimum, 5s. per ton. Station to Station. 1 to 24 miles inclusive, 0s. 6d. per ton per mile. 25 ,, 36 ,, 12 0 ,, 37 ,, 50 ,, 0 4 ,, per mile. 51 ,, 66 ,, 16 8 ,, 67 ,, 80 ,, 0 3 ,, per mile. 81 ,, 96 ,, 20 0 ,, 97 and upwards, 0 2½ ,, per mile.
Chloride of Sulphur -		
Chromic Acid Liquid (*also below*) - - - -		
Perchloride of Iron - -		
Painters' Solution, Corrosive (*also below*) - - -	In jars or carboys	
Reake's Vulcan Soldering Fluid - - - -	In carboys, earthenware jars, tins, or casks	
Sodium Amalgam - -	In iron drums hermetically sealed	
Solderine - - -	In carboys, earthenware jars, tins, or casks	
Tin Solution - - -	In jars or carboys, or in bottles packed in cases	

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* In the case of traffic to London charged according to this Mileage Scale, the charges are applicable only to the Stations of the Company carrying the traffic into London, and not beyond to any other London Station.

DESCRIPTION.	PACKING.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.
Section 2—continued.		
Chromic Acid Liquid (*also above*)	In carboys	In 4-ton loads, to be charged at Class C rates.
Painters' Solution (*also above*)	In jars or carboys NOTE.—Jars and glass or earthenware bottles only to be carried when protected by basket-work, and none exceeding 7 gallons in measure to be accepted for conveyance.	
Chromic Acid, Solid or Chromium Trioxide	In glass bottles, packed in cases	To be charged at Class 3 rates, Collected and Delivered.
	In casks or iron drums	To be charged at Class 1 rates, Collected and Delivered.
Disencrusting Fluids	In casks	To be charged at Class 2 rates, Collected and Delivered.
Sulphurous Acid	In casks	To be charged at Class 1 rates, Collected and Delivered.
Do.	In glass bottles (not carboys), packed in hampers	To be charged at Class 2 rates, Collected and Delivered.
Acetic or Wood Acid Arsenic Acid Carbolic Acid Chloride or Muriate of Zinc Iron Liquor or Muriate of Iron, or Chloride of Iron Nitrate of Iron Tin Liquor	As per General Railway Classification.	
	The articles in Section 2, as above, must not be loaded with other goods liable to be damaged thereby, and the services of loading and unloading must be performed by the owners, and not by the servants of the Company.	

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
MISCELLANEOUS. MATCHES, OILY GOODS, COMPRESSED GAS, &c.— Lucifer Matches - - Wax Matches - - Pipe Lighters, *Patent* -	In lots of 1 ton and upwards	4	Station to Station.	...	1. Cases, the gross weight of each of which does not exceed 2 cwt., to consist of wood at the sides, top, and bottom, ⅜ of an inch thick, ends ⅝ of an inch thick, to be strengthened with two battens across the lid outside, and two battens at each end, outside batten to be not less than 2½ inches wide and ½ inch thick. 2. Cases, the gross weight of each of which exceeds 2 cwt. and does not exceed 3 cwt., the sides, top, and bottom, to consist of wood ⅝ of an inch thick, and the ends ¾ of an inch thick, and to be strengthened by battens of the same width and thickness, and in the same positions as the 2 cwt. cases. 3. Where the cases are composed of wood thicker than the description mentioned above, battens need not be used. 4. Each case or package before delivery to the Company must have the contents labelled or branded on it in legibly written or printed characters. 5. Where Matches are mixed with Vesuvians or Fusees, the cases described for the latter must be used. NOTE.—As regards size and thickness of wood the above regulations do not apply to foreign imported Matches, if sent in cases such as those in which foreign Matches are being imported.
	In lots under 1 ton	5	Station to Station.	5/	
	The charge for quantities under 1 ton at the 5th class rate not to exceed the charges for 1 ton at 4th class rate.				
	In loads of 2 tons per truck	3	Station to Station.	...	
	The charge for quantities under 2 tons at the 4th class rate not to exceed the charge as for 2 tons at 3rd class rate.				

Table of Packing and Charges, &c.—*Continued.*

Description.	Charges. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
MISCELLANEOUS—*cont.*					
Safety Matches	In lots of 2 tons per truck	3	Station to Station	...	1. These are accepted for conveyance in packages of which the following is a description:— Half a gross boxes of Safety Matches are placed in another box made of boards ¼ inch thick, and measuring 5⅝ inches deep, 16 inches long, 8½ inches wide, and edges flush all round. This box is then wrapped up in brown paper. and tied with cord from end to end, and round the centre. Ten of these are then tied in one bundle with rope, and a piece of batten 4½ inches wide is placed across the top and bottom, for the purpose of strengthening the package. 2. Each case or package before delivery to the Company must have the contents labelled or branded on it in legibly written or printed characters.
	In lots of 1 ton and upwards	4	Station to Station	...	
	In lots under 1 ton- The charge for quantities under 1 ton at 5th class rate not to exceed the charge as for 1 ton at 4th class rate.	5	Station to Station	5/	
Vesuvians Fusees Gas-Lighting Explosive	In lots of 1 ton and upwards	4	Station to Station	...	1. Must be securely packed in strong boxes, the sides, bottoms, and lids of which must be of a thickness not less than ½ an inch, the ends not less than ¾ of an inch. The ends of the case must each be strengthened on the outer face by two battens not less than 2½ inches wide by ½ inch thick, and nailed to the sides. A piece of iron hooping or twisted wire must be nailed all round each end of the case. 2. Each case before delivery to the Company must have the contents labelled or branded on it in legibly written or printed characters. 3. Where Vesuvians or Fusees are mixed with Matches, the cases as above described for Vesuvians must be used.
	In lots under 1 ton The charge for quantities under 1 ton at 5th class rate not to exceed the charge as for 1 ton at 4th class rate.	5	Station to Station	5/	NOTE.—As regards size and thickness of wood, the above regulations do not apply to foreign imported Matches, if sent in cases such as those in which foreign Matches are being imported.

DESCRIPTION.	CHARGES. The charges herein provided, unless otherwise stated, are for conveyance at Owner's risk, and are subject to the scale for Small Parcels when that scale exceeds the minimum charges named.				Conditions of Carriage Supplementary to General Regulations.
		Class.	Condition.	Min. Charge.	
MISCELLANEOUS—*cont.* Carbonic Manifold Paper Oily Canvas Oily Canvas Clothing Oily Cap Peaks Oily Mill Sweepings Oily Paper Oily Rags Oily Sponge Cloths Oily Waste	...	2	Station to Station	2 tons	Carbonic Manifold Paper, Oily Canvas, Oily Paper must be packed in bales. Oily Canvas Clothing, Oily Cap Peaks must be packed in boxes or bales.
Vegetable Black	In casks	3	Collected and delivered	...	Must be packed in air-tight and damp-proof casks or cases.
Lamp Black	As per General Railway Classification.				Must be packed in air-tight and damp-proof casks or cases, or if carried in bags must be conveyed only in Gunpowder Vans.
Pintsch's Patent Compressed Gas	In iron tanks in Company's waggons	3	Station to Station	1 ton per truck.	In cylinders of wrought-iron or *of mild* steel of the best quality *containing not more than* 0.25 *per cent. of carbon, thoroughly annealed after manufacture*, of sufficient strength, and efficiently tested, and the cylinders securely protected by one of the following descriptions of packing:— (*a.*) Encased in closely plaited bemp. (*b.*) Fixed in ordinary wooden box without lid, but with rope handle. (*c.*) Loose in ordinary wooden box, with lid secured by strap. (*d.*) Efficiently protected by closely woven wicker-work, the valve of the cylinder not to project beyond the wicker-work. The traffic will not be received or conveyed unless securely packed as above. Returned Compressed Gas Empties, as above, to be charged at the ordinary Empties rate.
Compressed Oxygen Gas	...	2	Collected and delivered	...	
Compressed Hydrogen Gas Liquefied Anhydrous Ammonia or Compressed Ammonia Gas Compressed or Liquefied Carbonic Acid Gas Compressed or Liquefied Nitrous Oxide Gas	...	3	Collected and delivered	...	

COMPANIES WHICH DO NOT CARRY CERTAIN DANGEROUS GOODS OR CARRY UNDER RESTRICTIONS.

8. The following is a list of Companies which decline to carry certain Dangerous Goods, and of the articles which they so decline to carry; also of certain articles which are carried by them under restrictions :—

COMPANY. ARTICLES.

East London—

Will not carry Explosives or other Dangerous Goods.

Furness—

Will not carry Rubber Solution and all other Solutions partly composed of Naphtha.

Great Eastern—

Will not carry Explosives or other Dangerous Goods by any of their Steamers.

Great Western—

Will not carry Bisulphide of Carbon.

Will not carry through the Severn Tunnel—Gunpowder or other Explosive, Benzoline, Paraffin, Petroleum, or any of the Liquids included in Classes A and B of Inflammable Liquids.

Will not carry Explosives or Dangerous Goods, Compressed or Liquefied Carbonic Acid Gas, and Rubber Solution and all other Solutions partly composed of Naphtha, by any of their Steamers, but Lucifer Matches, Percussion Caps, and Safety Cartridges, when accompanied with a proper declaration and properly packed, will be conveyed at Owner's risk on the deck of the Company's Steamers between Milford and Waterford.

Lancashire and Yorkshire—

Will not carry in or upon any of the Joint Steamers between Fleetwood and Belfast—Oxygen Gas, Patent Pipe Lighters, Compressed or Liquefied Carbonic Acid Gas, Rubber Solution and all other Solutions partly composed of Naphtha, or any explosive, highly inflammable, or dangerous goods or goods of a dangerous nature, *except that the following articles, when sent in proper packages, and declared at Owner's risk, will be carried on the deck of the vessel, viz.* :—Bleaching Liquid, Bromine, Creosote in casks, Fluoric Acid, Fusees, Fuse, Lucifer Matches, Nitrate of Iron, Nitric Acid, Percussion Caps, and Safety Cartridges.

London and North-Western—

Will not carry in or upon any of their Vessels between Holyhead and Dublin, and Holyhead and Greenore, or in or upon any of the Joint Steamers between Fleetwood and Belfast—Oxygen Gas, Patent Pipe Lighters, Compressed or Liquefied Carbonic Acid Gas, Rubber Solution and all other Solutions partly composed of Naphtha, or any explosive, highly inflammable, or dangerous goods or goods of a dangerous nature, *except that the following articles, when sent in proper packages and declared at Owner's risk, will be carried on the deck of the vessel, viz.*:—Bleaching Liquid, Bromine, Creosote in casks, Fluoric Acid, Fusees, Fuse, Lucifer Matches, Nitrate of Iron, Nitric Acid, Percussion Caps, and Safety Cartridges.

London and South-Western—

Will not carry Bisulphide of Carbon.

Will not carry by any of their Steamers—

Lamp Black,
Vegetable Black,
Compressed Oxygen Gas, nor
Explosive or Dangerous Goods, except the following, viz.:—

In casks or iron drums—

Acetic Acid.
Arsenic Acid.
Carbolic Acid.
Methylated Spirit.
Spirit of Wine.
Spirit Varnish.
Terebine or Sun Dryers.
Turpentine Varnish.
Turpentine.

Turpentine, in iron tapers, securely hooped top and bottom.

NOTE.—The Southampton Harbour Board having prohibited the landing and shipping of Explosives in Classes 2, 3, 4, and 5, viz., Nitrate Mixture, Nitro-Compound, Chlorate Mixture, and Fulminate, at or from any Public Quay or Landing Place within their jurisdiction, such Explosives cannot be accepted for through conveyance to the Isle of Wight, *via* Southampton, and must only be accepted if consigned to Southampton; the owners to make their own arrangements for shipment to the Island from some private wharf under conditions sanctioned by the Harbour Board. Explosives in Classes 1, 6, and 7, viz., Gunpowder, Ammunition, and Fireworks, can still be loaded or shipped at the Public Quay at Southampton, provided the total quantity of each landing or shipment does not exceed 10 cwts.

London, Brighton, and South Coast—

Will not carry Bisulphide of Carbon.

Will not carry
Explosive or Dangerous Goods, Compressed or Liquefied Carbonic Acid Gas, or Rubber Solution and all other Solutions partly composed of Naphtha
Lamp Black
Vegetable Black
by any of their Steamers.

London, Chatham, and Dover—

Will not carry Bisulphide of Carbon.

Will not carry
Explosive or Dangerous Goods, Compressed or Liquefied Carbonic Acid Gas or Rubber Solution and all other Solutions partly composed of Naphtha
Lamp Black
Vegetable Black
by any of their Steamers.

London, Tilbury, and Southend—

Will not carry Bisulphide of Carbon.

Manchester, Sheffield, and Lincolnshire—

Will not carry by their Steamers any of the more dangerous class of Explosives, such as Non-Safety Cartridges, Gunpowder, Roburite, Amberite, Oxygen Gas, Patent Pipe Lighters, Potentite, or any highly inflammable or dangerous Solutions. The following articles, when sent in proper packages, and declared at Owner's risk, will be carried on the deck of the Steamers, viz., Safety Cartridges, Percussion Caps, Matches, Acids, Detonators, Turpentine, and Mineral Oils which do not give off an inflammable vapour at a temperature of less than 73° Fahrenheit.

Metropolitan—

Decline to carry all Explosives, and also Mineral Oils giving off an inflammable vapour at less than 73° Fahrenheit, when tested in the manner set forth in the Petroleum Act, 1879.

North London—

Decline to carry all Explosives.

South Eastern—

Will not carry Bisulphide of Carbon.

Will not carry {
Explosive or Dangerous Goods, Compressed or Liquefied Carbonic Acid Gas, or Rubber Solution and all other Solutions partly composed of Naphtha
Lamp Black
Vegetable Black
} by any of their Steamers.

Wotton Tramway—

Will not carry Bisulphide of Carbon.

Barrow Steam Navigation—

Goods to be carried on deck only, at Owner's risk:—

Acids of all kinds in proper packages.
Bleaching Liquid.
Bromine.
Cartridges (Safety).
Fusee Matches, properly labelled as such.
Inodorous Felt.
Lucifer Matches, properly labelled as such.
Nitrate of Iron.
Oily Waste.
Vitriol, in carboys only.

Oils to be carried on deck or in hold, at Owner's risk:—

Mineral Oils which do not give off an inflammable vapour at a temperature of less than 73° Fahrenheit.

(*Full particulars of the nature of each consignment must be given in the invoice, for the guidance of the Barrow Steam Navigation Company's staff.*)

Barrow Steam Navigation—*Continued.*

Goods not to be carried under any circumstances:—

- *Benzoline.
- Bisulphide of Carbon.
- Cartridges (Non-Safety).
- Compressed or Liquefied Carbonic Acid Gas.
- Ether.
- Fire-filled Shells.
- Fireworks, or any articles composed in part of Gunpowder.
- Fog Signals.
- Grain, in bulk.
- Gunpowder.
- Long Lights.
- *Naphtha.
- *Naphthaline.
- Percussion Caps.
- *Petroleum.
- *Phosphorus, in cases or otherwise.
- Port Fires.
- Quickmatch.
- *Rock Oil.
- Rubber Solution, and all other Solutions partly composed of Naphtha.
- Wood Naphtha, and all other goods of a similar nature.

* *Giving off an inflammable vapour at less than* 73° *Fahrenheit.*

Belfast Steam Ship, between Liverpool and Belfast—

Goods not carried in any of the Company's Steamers under any circumstances whatever:—

- Benzoline or Gasoline.
- Fire-filled Shells.
- Gunpowder.
- Long Lights.
- Naphthaline.
- Quickmatch.
- Naphtha.

City of Cork Steam Packet—

Goods not to be carried under any circumstances:—

- Any of the articles comprised in Classes 1 to 7, or articles of a similar or like nature.
- Gas Lighting Explosives.
- Any Spirit giving off inflammable vapour at less than 73° Fahr.
- Bisulphide of Carbon.
- Gazogen.
- Hydrogen Gas.
- Nitrous Oxide Gas.
- Inflammable Liquids, Class A.

Goods to be carried on deck only, at Owner's sole risk:—

- Remainder of the articles classified as Dangerous.
- Safety Cartridges for the Government.
- All Acids, which must be packed in exposed carboys or packages entirely painted in red, with a large card about 1 foot square attached, with the words "Acid, on Deck," painted thereon in letters about 2 inches long.

City of Dublin Steam Packet—

Will not carry under any circumstances:—

Acids.
Creosote.
Esparto (loose).
Flax (loose).
Hay (loose).
Hemp (loose).
Inodorous Felt.
Naphtha.
Oily Clothing.
Paraffin.
Petroleum, or other Explosives.
Mineral Oils.
Cartridges, or any other Dangerous Goods.

Glasgow, Dublin, and Londonderry Steam Packet—

Goods to be carried on deck only, at Owner's risk:—

Acids of all kinds in proper packages.
Bleaching Liquid.
Bromine.
Cartridges (Safety).
Fusee Matches, properly labelled as such.
Inodorous Felt.
Lucifer Matches, properly labelled as such.
Nitrate of Iron.
Oily Waste.
Vitriol, in carboys only.

Oils to be carried on deck or in hold, at Owner's risk:—

Mineral Oils which do not give off an inflammable vapour at a temperature of less than 73° Fahrenheit.

(*Full particulars of the nature of each consignment must be given in the invoice, for the guidance of the Glasgow, Dublin, and Londonderry Steam Packet Company's staff.*)

Goods not to be carried under any circumstances:—

Benzoline.
Bisulphide of Carbon.
Cartridges (Non-Safety).
Compressed or Liquefied Carbonic Acid Gas.
Ether.
Fire-filled Shells.
Fireworks, or any articles composed in part of Gunpowder.
Fog Signals.
Grain, in bulk.
Gunpowder.
Long Lights.
Naphtha.
Naphthaline.
Percussion Caps.
Petroleum.
Phosphorus, in cases or otherwise.
Port Fires.
Quickmatch.
Rock Oil.
Rubber Solution, and all other Solutions partly composed of Naphtha.
Wood Naphtha, and all other goods of a similar nature.

Larne and Stranraer Steamboat Company—

Will not carry Compressed or Liquefied Carbonic Acid Gas by their Steamers.

SPECIAL CONSIGNMENT NOTES AND ADVICE NOTES.

9. The following Special Forms of Consignment Note and Advice Note must always be used, and in quoting rates for Explosives and other Dangerous Goods it is desirable that a copy of the proper Form of Consignment Note should be sent along with the quotation.

No. 1.—Consignment Note for Gunpowder or other Explosive.

..............................RAILWAY COMPANY.

CONVEYANCE OF GUNPOWDER OR OTHER EXPLOSIVE.

In order, as far as possible, to prevent accidents arising from the conveyance of Gunpowder or other Explosive on the Railway, the Company decline to receive any such goods except under the provisions of the Code of Bye-Laws, dated..................1876, made with the sanction of the Board of Trade, in pursuance of the Explosives Act, 1875, for the regulation of the Loading, Unloading, and Conveyance of Explosives on the Railways of the Company, copies of which Bye-Laws are exhibited at the Railway Stations, and may be obtained on application to the Secretary of the Company.

The following are some of the Bye-Laws principally affecting the Consignors and Consignees of Explosives, viz. :—

"2. No person shall send to the Company any consignment of Explosive, unless he has given to the Company forty-eight hours' previous notice in writing of his intention to send such consignment, and stating the true name, description, and quantity of the Explosive proposed to be conveyed, and his own name and address, and also the name and address of the proposed consignee, and has had an intimation in writing from the Company that they are prepared to receive such consignment.

"3. Consignments of Explosive shall be sent to the Company's forwarding station, and shall be received by their servants, only at such times during the hours of daylight, that is to say, between sunrise and sunset, as the Company may appoint; and every consignment and package containing any Explosive proposed to be conveyed on any railway of the Company shall immediately on the arrival thereof at the Company's station, wharf, or sailway, be delivered to and be received by the Company's servants authorised to receive dangerous goods, and by no other person whatsoever.

"4. No Explosive shall be loaded or unloaded on the Company's premises by the consignor or consignee thereof or their servants, except between sunrise and sunset."

"13. When the stowing of Explosive in any carriage or the loading or unloading of any Explosive is undertaken by any person other than the Company, all due precautions shall be taken by such person, by careful stowing and loading and unloading and otherwise, to prevent and secure such Explosive from being brought into contact with or endangered by any other article or substance liable to cause fire or explosion.

"14. In loading or unloading any Explosive, the casks and packages containing the same shall, as far as practicable, be passed from hand to hand, and not rolled upon the ground, and in no case shall any such casks or packages be rolled, unless hides, cloths, or sheets have been previously laid down on the platform or ground over which the same are to be rolled. Casks or packages containing Explosive shall not be thrown or dropped down, but shall be carefully deposited and stowed.

"15. No person while employed in loading, stowing in any carriage, or unloading any Explosive included in Classes 1, 2, 3, 4, or 5 of the classification of Explosives as classified by the said Order in Council, dated 5th August 1875, shall wear boots or shoes with steel or iron nails, steel or iron heels, or tips of any kind, or have about his person any lucifer match, explosive, or means of striking a light; and all persons employed in the loading, stowing, or unloading of any Explosive shall, while such loading, stowing, or unloading are going on, abstain from smoking.

"16. While the loading, unloading, or conveyance of Explosive is going on, all persons engaged in such loading, unloading, or conveyance shall observe all due precautions for the prevention of accidents by fire or explosion, and for preventing unauthorised persons having access to the Explosive so being loaded, unloaded, or conveyed, and shall abstain from any act whatever which tends to cause fire or explosion, and is not reasonably necessary for the purpose of loading, unloading, or conveyance of such Explosive, or of any other article carried therewith, and for preventing any other person from committing any such act; and such other person who, after being warned, commits any such act shall be deemed to commit a breach of these Bye-Laws.

"17. The loading or unloading of Explosive into or out of any carriage, when once begun, shall be proceeded with with all due diligence until the same is completed.

"18. Packages containing any Explosive must be removed by the consignee from the station, wharf, or depôt of the Company to which they have been conveyed as soon as practicable, and with all due diligence after arrival; and if not removed within twelve hours after arrival the packages and contents may be forthwith sold by the Company, or otherwise disposed of as they think fit; and such packages shall in the meantime, and until such removal, sale, or disposal, be completely covered over with painted cloth, tarpaulin, or other suitable material."

"20. These Bye-Laws are supplemental to the Explosives Act, 1875: and in the event of any breach (by any act or default) of any of them, or any attempt to commit such breach, the following penalties and consequences will be incurred and ensue, that is to say:—

"(1.) The Explosive in respect of which, or being in the carriage, or train of carriages, in respect of which, the offence is committed, may, unless the offence be committed by the Company, be forfeited to the Company.

"(2.) The person committing the offence shall be liable to a penalty not exceeding £20 for each offence, and to a further penalty of £10 for each day during which the offence continues; and the owner of the carriage, or train of carriages in respect of which, or containing the Explosive in respect of which, the offence is committed, the person in charge of such carriage, and the owner of such Explosive, shall each be liable to a similar penalty."

Subject to the provisions of the before-mentioned Code of Bye-Laws, Gunpowder or other Explosive, except ordinary Fireworks, will be received at the Railway Station only on the forenoons of....................days and ....days.

Ordinary Fireworks will be received at the Station on the forenoons of ....days.

No Gunpowder or other Explosive will be received or conveyed unless plainly and fully addressed to the consignee, and unless upon the outermost package containing the same there shall be written or printed or affixed, in conspicuous characters, by means of a brand, securely attached label, or otherwise, the description of the inner package, and the word "Explosive," followed by the name of the Explosive, and the class and division to which it belongs, together with the name and address of the owner and sender. And further, no Gunpowder or other Explosive will be received or conveyed unless securely packed in strong, secure, and sufficient packages, and the packages are in good condition.

If the goods be not accepted in due course by the consignee, they will, in the option of the Company, be forthwith sold by the Company, or returned to the sender, who will, if they be returned, be bound to receive them at once and pay all the charges incurred for carriage, back carriage, and re-delivery.

The Company do not undertake or incur the duties or liability of common carriers in respect of goods received or conveyed under this agreement, nor are the Company to incur any risk or responsibility in respect of the loading, stowage, or unloading; nor in respect of any loss or damage arising in or by reason of the loading, stowage, or unloading thereof; nor are they to be answerable for any loss or damage, actual or consequential, nor for discrepancy in the delivery as to either quantity, number, or weight, nor for the condition of any such goods, nor for over-carriage of the goods, nor for detention, or delay in, or in relation to, the conveying or delivery thereof, arising from any cause whatever other than proved gross neglect or fraud on the part of the Company's servants.

The foregoing Regulations and Conditions, and the Bye-Laws contained in the above-mentioned Code of Bye-Laws, are applicable throughout the entire distance over which the goods are to be carried, and none of them can be altered or dispensed with by any person whomsoever.

....................STATION,.......... 189

The.......................Railway Company are requested to receive and forward, as per address and particulars given, the goods named on the other side hereof, subject to the Regulations and Conditions stated above, and the provisions of the Code of Bye-Laws above referred to, to all of which.................hereby agree.

Signature of Sender.:..

Address..

PARTICULARS OF GOODS TO BE FORWARDED.

... .STATION,....................189

Owner and No. of Truck.	No. of Invoice.	Consignee.	Address.	No. of Articles.	Description of Goods and Marks.	Weight.				Charges Paid on.			Who pays the Carriage.
						Tons	Cwts.	Qrs.	Lbs.	£	s.	d.	

Checked by.................... *Loaded by*....................

No. 2.—Special Advice Note of Gunpowder or other Explosive.

....RAILWAY COMPANY.

GOODS DEPARTMENT.

....................STATION,....................189

M..

The undermentioned goods, consigned to you under special conditions and subject to the provisions of the Code of Bye-Laws, dated.................. 1876, made with the sanction of the Board of Trade in pursuance of the Explosives Act, 1875, for regulating the loading, unloading, and conveyance of Explosives on the Railways of the Company, having arrived here, please order their immediate removal hence, as they remain here at your sole risk; and if not removed within six hours after delivery of this notice, Five Shillings per ton per hour demurrage will be charged, and if not removed within a period of twelve hours from the time of their arrival, the goods will be forthwith sold by the Company or otherwise disposed of.

No delivery allowed after..................o'clock in the evening or before ....o'clock in the morning.

Your obedient Servant,

....

....................*Railway.*

Species of Goods.	Marks.	Weight.				Rate.	Paid on.			Carriage.			Cartage.	TOTAL.		
		T.	C.	Qrs	Lbs		£	s.	d.	£	s.	d.		£	s.	d

Invoice No....................... *Waggon No.*....................

When you send for the above goods, please send this note.

No. 3.—Consignment Note for Inflammable Liquids, Class A (Vapour Inflammable under 73°).

Consignment Note and Contract *for the carriage of Inflammable Liquids* (*Class A*), *which when tested in the manner set forth in the "Petroleum Act, 1879," give off an inflammable vapour at a temperature of less than 73° of Fahrenheit's thermometer.*

.....................189

The.................. .....Railway Company are requested to receive and forward the undermentioned goods from their.....................Station to the Station at......... ....

Consignee.	Residence.	Description of Goods giving off inflammable vapour at less than 73° Fahr.	Weight.				
			Tons	Cwts.	Qrs.	Lbs.	

In consideration of the Company accepting the above-mentioned goods for carriage, as aforesaid, I, the undersigned (sender), undertake and agree—(1) That the said goods are to be carried at my sole risk, and that the Company are not under any circumstances to be liable for any loss of, or injury to, the said goods, nor for any delay or detention thereof arising from any cause whatever other than proved gross neglect or fraud on the part of the Company's servants; (2) That the goods are to be removed by the consignee from the station to which they are consigned within two working hours after delivery to the consignee of the advice note of arrival, and that in default of such removal, and so long as the goods or any part thereof remain on the premises of the Company, the Company will be entitled to charge and recover from me Five Shillings per ton per hour as and for liquidated damages, and further, if not removed within twelve working hours after delivery of the advice note, the Company may sell the goods and retain out of the proceeds of sale all the charges payable for carriage, and all charges and expenses incidental to such sale, and also all moneys payable under or by virtue of this agreement.

In witness whereof I have hereunto set my hand the day and year first above written.

Signature of Sender....................... ....

No. 4.—Special Advice Note for Inflammable Liquids, Class A (Vapour Inflammable under 73°).

..............................Railway.

Special Advice Note *of Inflammable Liquids* (*Class A*), *which when tested in the manner set forth in the "Petroleum Act, 1879," give off an inflammable vapour at a temperature of less than 73° of Fahrenheit's thermometer.*

GOODS DEPARTMENT.

....................Station,.....................189

M......................................

The undermentioned goods consigned to you having arrived here, please order their immediate removal hence, as they remain here at your sole risk; and if not removed within two hours after delivery of this notice, Five Shillings per ton per hour demurrage will be charged, and if not removed within twelve working hours, the goods will be forthwith sold by the Company.

Your obedient Servant,

....

.....................*Railway.*

Species of Goods.	Marks.	Weight.				Rate.	Paid on.			Carriage.			Cartage.	TOTAL.		
		T.	C.	Qrs	Lbs		£	s.	d.	£	s.	d.		£	s.	d.

Invoice No..................... *Waggon No*............... .....

When you send for the above goods, please send this note.

No. 5.—Special Consignment Note and Advice Note for Bisulphide of Carbon.

The following Special Forms of Consignment Note and Advice Note must always be used, and in quoting rates for Bisulphide of Carbon it is desirable that a copy of the proper Form of Consignment Note should be sent along with the quotation :—

CONSIGNMENT NOTE FOR THE CARRIAGE OF BISULPHIDE OF CARBON.

The.................. ...Railway Company give notice that they will not carry Bisulphide of Carbon unless the following conditions are strictly complied with, and the Contract hereinafter appearing is signed by the person or firm on whose behalf the Bisulphide of Carbon is sent :—

Conditions.

(*a.*) Each drum tendered for conveyance must be securely placed in wooden cradles in three sections, and protected at each end by wooden bars to prevent concussion during transit.

(*b.*) The gross weight of each drum must not exceed 5 cwts.

(*c.*) The drums must be made of wrought iron or steel of a thickness of not less than ¼ of an inch for drums up to 15 inches diameter. For drums of large diameter the thickness must increase in proportion so as to allow the usual margin of safety.

(*d.*) The drums must have been tested by senders by hydraulic pressure of not less than 75 lbs. to the square inch, and also re-tested whenever they have shown signs of damage or deterioration afterwards, the test being repeated at least once every year. After filling, and before being handed to the Railway Companies for conveyance, the drums must be tested by sender to ensure that there is no evaporation or leakage.

(*e.*) The drums must be whitened from time to time as necessary with a mixture of whitening and oil.

(*f.*) The screw plugs by which the drums are closed must be made of brass, with shoulders, and be fitted with washers made of lead.

(*g.*) The screw plugs must be securely fastened in their places before the empty drums are returned.

(*h.*) When filling the drums the senders must leave an air space equal to $\frac{1}{20}$th of the capacity of each drum, so as to allow room for expansion of the liquid consequent upon changes of temperature.

In consideration of the......................Railway Company consenting to carry the Bisulphide of Carbon which may be delivered to them for carriage on my behalf, I hereby undertake and agree :—

1. That the above Conditions shall be in all respects complied with in regard to all such Bisulphide of Carbon.

2. That the Company shall not be liable for any loss of or delay or injury to such Bisulphide of Carbon, unless such loss, delay, or injury is proved to have been caused by the wilful misconduct of the Company's servants.

3. That I will indemnify the Company against all claims for injury to person or property arising directly or indirectly from the inflammable or explosive qualities of such Bisulphide of Carbon, and will pay reasonable compensation for all injury to their servants and damage to their property so arising.

4. That the goods are to be removed by the consignee from the station to which they are consigned within two working hours after delivery to the consignee of the advice note of arrival, and that in default of such removal, and so long as the goods or any part thereof remain on the premises of the Company, the Company will be entitled to recover and charge from me Five Shillings per ton per hour as and for liquidated damages, and further, if not removed within twelve working hours after delivery of the advice note, the Company may destroy or dispose of the goods as they think expedient for preventing danger, or may sell the goods and retain out of the proceeds of sale all the charges payable for carriage, and all charges and expenses incidental to such destruction, disposal, or sale, and also all moneys payable under or by virtue of this agreement.

5. That the above Conditions and Contract shall apply not only to the ....Railway Company but to any other Company or person in whose custody such Bisulphide of Carbon may be during transit, or in pursuance of the contract to carry or in any way incidental thereto.

Signature of Sender..

Address.............................. ....

No. 6.—Special Advice Note for Bisulphide of Carbon.

...................RAILWAY.

GOODS DEPARTMENT.

...................STATION,..... 189

M..

The undermentioned goods consigned to you having arrived here, please order their immediate removal hence, as they remain here at your sole risk; and on behalf of the Company I hereby give you notice that if the same are not removed within two hours after delivery of this notice, Five Shillings per ton per hour as and for liquidated damages will be charged, and if not removed within twelve working hours after the delivery of this note, the goods may be forthwith destroyed or disposed of as thought expedient for preventing danger, or sold by the Company in pursuance of the special conditions under which this Company undertake to carry Bisulphide of Carbon.

Your obedient Servant,

....

....................*Railway.*

Species of Goods.	Marks.	Weight.				Rate.	Paid on.			Carriage.			Cartage.	TOTAL.		
		T.	C.	Qrs	Lbs		£	s.	d.	£	s.	d.		£	s.	d.

Invoice No..................... *Waggon No*......................

When you send for the above goods, please send this note.

No. 7.—Consignment Note for Inflammable Liquids, Class B (Vapour Inflammable between 73° and 150°).

Pro No..........

....RAILWAY.

CONSIGNMENT NOTE FOR INFLAMMABLE LIQUIDS, CLASS B.

Penalty for False Declaration, £20. (*Railway Clauses Act*, 8 *Vict. c.* 20, *Cl.* 105.)

.....................STATION,...............189

The.......................Railway Company are requested to receive and forward, as per address and particulars on this note, the undermentioned packages containing Inflammable Liquids (Class B), which,.........hereby declare, will not give off inflammable vapour at a less temperature than 73° Fahrenheit, when tested in the manner set forth in the Petroleum Act, 1879; but which will give off an inflammable vapour at a temperature from 73° to 150° Fahrenheit.

Sender..

Address ....

Owner and No. of Truck.	No. of Invoice.	Consignee.	Address.	No. of Articles.	Description of Goods and Marks.	Weight.				Charges Paid on.			Who pays the Carriage.
						Tons	Cwts.	Qrs.	Lbs.	£	s.	d.	

No. 8.—Consignment Note for Mineral Oils (Vapour not Inflammable at less than 150°).

Pro No......................

......................RAILWAY.

CONSIGNMENT NOTE FOR MINERAL OILS.

Penalty for False Declaration, £20. (*Railway Clauses Act*, 8 *Vict.* *c.* 20, *Cl.* 105.)

.....................STATION,.....................189

The.......................Railway Company are requested to receive and forward, as per address and particulars on this note, the undermentioned packages containing Mineral Oils, which,......hereby declare, will not give off inflammable vapour at a less temperature than 150° Fahrenheit.

Sender..

Address..

Owner and No. of Truck.	No. of Invoice.	Consignee.	Address.	No. of Articles.	Description of Goods and Marks.	Weight.				Charges Paid on.			Who pays the Carriage.
						Tons	Cwts.	Qrs.	Lbs.	£	s.	d.	

No. 9.—Consignment Note for Dangerous or Corrosive Chemicals, Matches, and similar Dangerous Goods.

.....................RAILWAY COMPANY.

CONVEYANCE OF DANGEROUS GOODS

(OTHER THAN GOODS SUBJECT TO THE EXPLOSIVES ACT, 1875).

In order, as far as possible, to prevent accidents arising from the conveyance of Corrosive Acids, Lucifer Matches, Fusces, and similar Dangerous Goods, on the Railway, the Company decline to receive or convey any such goods except under the following Regulations and Conditions:—

1. Acids and all other dangerous goods (except Explosives as above referred to, and except those mentioned below) will be received at the Railway Station only on the forenoons of ....days and ....days.

2. Fusces, Gas-lighting Explosive, and Lucifer and other Matches, will be received at the Stations on the forenoons of ....days.

3. No goods of the class above mentioned will be received or conveyed unless plainly and fully addressed to the consignee, and the name of the contents of each package and the description of the inner package be written or printed in conspicuous characters on the outside of the outermost package containing the same; and unless securely packed in strong, secure, and sufficient packages, and the packages be in good condition. The Company will not allow any such goods to remain on their premises longer than is absolutely necessary; and if they be not accepted in due course by the consignee, they will, in the option of the Company, be forthwith sold by the Company or returned to the sender, who will, if they be returned, be bound to receive them at once and pay all the charges incurred for carriage, back carriage, and re-delivery.

4. The Company do not undertake or incur the liability or duties of common carriers in respect of goods received or conveyed under this Agreement, nor are the Company to incur any risk or responsibility in respect of the loading, stowage, or unloading; nor in respect of any loss or damage arising in or by reason of the loading, stowage, or unloading thereof; nor are they to be answerable for any loss or damage, actual or consequential, nor for discrepancy in the delivery as to either quantity, number, or weight, nor for the condition of any such goods, nor for over-carriage of the goods, nor for detention or delay in, or in relation to, the conveying or delivery thereof, except upon proof of gross neglect or fraud on the part of the Company's servants.

5. Senders of dangerous goods omitting to give notice in writing of the contents of packages containing such goods are liable to a penalty of £20.

6. These Regulations and Conditions are applicable throughout the entire distance over which the goods are to be carried, and none of them can be altered or dispensed with by any person whomsoever.

... .STATION, ...189

The......................Railway Company are requested to receive and forward, as per address and particulars on this note, the undermentioned goods, on the Regulations and Conditions stated above, to all of which ....hereby agree.

Sender......................................

Address...................... ....

Owner and No. of Truck.	No. of Invoice.	Consignee.	Address.	No. of Articles.	Description of Goods and Marks.	Weight.				Charges Paid on.			Who pays the Carriage.
						Tons	Cwts.	Qrs.	Lbs.	£	s.	d.	

Checked by.......................... *Loaded by*..................... ......

No. 10.—Special Advice Note of Dangerous or Corrosive Chemicals, Matches, and similar Dangerous Goods.

....................RAILWAY COMPANY.

GOODS DEPARTMENT.

....STATION, ...189

M........... ....

The undermentioned goods, consigned to you under special conditions, having arrived here, please order their immediate removal hence, as they remain here at your sole risk; and if not removed within two hours after delivery of this notice, Five Shillings per ton per hour demurrage will be charged, and if not removed within a further period of twelve hours, the goods will be forthwith sold by the Company or returned to consignor.

Your obedient Servant,

....

....................*Railway*.

Species of Goods.	Marks.	Weight.				Rate.	Paid on.			Carriage.			Cartage.	TOTAL.		
		T	C.	Qrs	Lbs		£	s.	d.	£	s.	d.		£	s.	d.

Invoice No.......... ... *Waggon No.*............

When you send for the above goods, please send this note.

No. 11.—Consignment Note and Contract for the Carriage of Oily Rags, Oily Waste, and Oily Mill Sweepings, Oily Paper, Oily Canvas, Oily Cap Peaks, Oily Canvas Clothing, Oily Sponge Cloths, and Carbonic Manifold Paper.

......................189

The........................Railway Company are requested to receive and forward the undermentioned goods from their.....................station to the station at.....................

Consignee.	Residence.	Description.	Weight.				Who pays carriage.
			Tons	Cwts.	Qrs.	Lbs.	

In consideration of the Company accepting the above-mentioned goods for carriage, as aforesaid, I, the undersigned (sender), undertake and agree—(1) That the goods are to be carried at my sole risk, and that the Company are not, under any circumstances, to be liable for any loss of, or injury to, the said goods, nor for any delay or detention thereof arising from any cause whatever, other than proved gross neglect or fraud on the part of the Company's servants; (2) That the goods are to be removed by the consignee from the station to which they are consigned within twenty-four hours after delivery to the consignee of the advice note of arrival, and that in default of such removal the Company may deposit the goods on any public wharf or place of deposit at my expense, or sell the same, and retain out of the proceeds of such sale all the charges payable for carriage, and all charges and expenses incidental to such sale.

In witness whereof I have hereunto set my hand the day and year first above written.

Signature of Sender..

No. 12.—Special Advice Note of Oily Rags, Oily Waste, Oily Mill Sweepings, Oily Paper, Oily Canvas, Oily Cap Peaks, Oily Canvas Clothing, Oily Sponge Cloths, Carbonic Manifold Paper, and Compressed Gases.

....RAILWAY COMPANY.

GOODS DEPARTMENT.

.....................STATION,.....................189

M.. ....

The undermentioned goods, consigned to you under special conditions, having arrived here, please order their immediate removal hence, as they remain here at your sole risk; and if not removed within twenty-four hours after delivery of this notice, the goods will be removed from the Company's premises at your expense, or sold.

Your obedient Servant,

....

.....................*Railway*.

Species of Goods.	Marks.	Weight.				Rate.	Paid on.			Carriage.			Cartage.	TOTAL.		
		T.	C.	Qrs	Lbs		£	s.	d.	£	s.	d.		£	s.	d.

Invoice No............ *Waggon No*............

When you send for the above goods, please send this note.

No. 13.—Consignment Note for the Carriage of Compressed Gases.

.....................RAILWAY COMPANY.

In order, as far as possible, to prevent accidents arising from the conveyance of compressed gases on the railway, the Company only receive or convey such goods under the following Regulations and Conditions:—

1. The traffic will not be received or conveyed unless securely enclosed in cylinders of wrought iron or of mild steel of the best quality, containing

not more than 0.25 per cent. of carbon, thoroughly annealed after manufacture, of sufficient strength and efficiently tested, and the cylinders securely protected by one of the following descriptions of packing:—

(*a.*) Cylinder encased in closely plaited hemp.
(*b.*) Cylinder fixed in ordinary wooden box without lid, but with rope handle.
(*c.*) Cylinder loose in ordinary wooden box, with lid secured by strap.
(*d.*) Cylinder efficiently protected by closely woven wicker-work, the valve of the cylinder not to project beyond the wicker-work.

2. The Company do not undertake or incur the liability or duties of common carriers in respect of goods received or conveyed under this agreement, nor are the Company to incur any risk or responsibility in respect of same.

3. In respect of any goods booked through by them or their agents for conveyance, partly by railway and partly by sea, or partly by canal and partly by sea, the Company shall be exempted from liability for any loss, damage, or delay which may arise during the carriage of any such goods by sea, from the act of God, the Queen's enemies, fire, accidents from machinery, boilers, and steam, and all and every other dangers and accidents of the seas, rivers, and navigation, of whatever nature and kind soever, in the same manner as if the Company had signed and delivered to the consignor a bill of lading containing such condition.

4. The transit shall in no case extend beyond (*a*) the time when goods carted by the Company are unloaded or tendered at the address to which they are consigned; or (*b*) the expiration of twenty-four hours after notice of arrival of the goods, posted by the Company, is due for delivery to the consignee in the ordinary course of post, or notice of arrival is given to him personally or delivered at his address.

5. After the termination of the transit, as defined in Condition 4, the Company will henceforth, and subject to these conditions, hold the goods as warehousemen, subject to the usual charges.

6. All goods delivered to the Company will be received and held by them subject to a lien for money due to them for the carriage of, and other charges upon, such goods, and also to a general lien for any other moneys due to them from the owners of such goods upon any account, and in case any such lien is not satisfied within a reasonable time from the date upon which the Company first gave notice to the owners of the goods of the exercise of the same, the goods may be sold by the Company by auction or otherwise, and the proceeds of sale applied to the satisfaction of every such lien and expenses.

7. In respect of goods consigned to places beyond the limits of the Company's free delivery, the responsibility of the Company will cease when such goods have been delivered over to another carrier in the usual course for delivery.

8. In all cases where the Company's charges are not prepaid, the goods are accepted for carriage only upon the condition that the sender remains

liable for the payment of the amount due to the Company for the carriage of such goods, without prejudice to the Company's rights, if any, against the consignee or any other person.

Senders of dangerous goods omitting to give notice in writing of the actual contents of packages containing such, are liable to a penalty of £20.

……………………STATION,……………………189

The……………………Railway Company are requested to receive and forward by goods train, as per address and particulars on this note, the undermentioned goods, under the Regulations and Conditions named herein, to all of which $\frac{\text{we}}{\text{I}}$ hereby agree. $\frac{\text{We}}{\text{I}}$ hereby certify that the consignment complies with the conditions that the cylinder or cylinders must be of wrought iron or of mild steel of the best quality, containing not more than 0.25 per cent. of carbon, thoroughly annealed after manufacture, of sufficient strength, and efficiently tested.

Signature of Sender……………………………………

Address……………………………………

Owner and No. of Truck.	No. of Invoice.	Consignee.	Address.	No. of Articles.	Description of Goods and Marks.	Weight.				Charges Paid on.			Who pays the Carriage
						Tons	Cwts.	Qrs.	Lbs.	£	s.	d.	

Checked by…………………… *Loaded by*……………………

10. DESCRIPTION OF THE GOVERNMENT CYLINDERS FOR CONVEYANCE OF AMMUNITION BY RAILWAY, REFERRED TO IN REGULATIONS 3 AND 7.

HALF BARREL.

The general dimensions of the cylinder are to be in conformity with Drawing No. 1294, $\frac{M}{82}$. (*This drawing is in the custody of the Railway Clearing House.*)

The body of the cylinder is to be made of Best Best Staffordshire Iron, No. 15 B.W.G., 17.8 inches in length (inside), and 14.5 inches internal diameter.

The bottom and cover are to be made of gun metal, 16.9 inches external diameter, and riveted to the body by eighteen copper rivets.

The top of the cylinder has an angular gun metal ring, 16.9 inches diameter, with six small grooves on the surface, their object being to allow a leather washer (used in making an air-tight joint between the top ring and cover) to be jammed into them, and thus forming a more perfect joint.

The cover is to have small grooves as described for ring.

The leather washer is laid on the top ring and the cover placed over it, and secured by four square-headed screws, .5 inch in diameter.

The iron cylinder and screws are to be tinned all over previous to securing the gun metal bottom and top angular ring to it. (The gun metal does not require tinning.)

When finished, the cylinder is to receive a coating of Brunswick black in the interior, and two coats of dark green paint on the exterior.

QUARTER BARREL.

The general dimensions of the cylinder are to be in conformity with Drawing No. 1295, $\frac{\text{M}}{83}$. (*This drawing is in the custody of the Railway Clearing House.*)

The body of the cylinder is to be made of Best Best Staffordshire Iron, No. 15 B.W.G., 14.8 inches in length (inside) and 12.5 inches internal diameter.

The bottom and cover are to be made of gun metal, 14.6 inches external diameter, and riveted to the body by eighteen copper rivets.

The top of the cylinder has an angular gun metal ring, 14.6 inches diameter, with five small grooves on the surface, their object being to allow a leather washer (used in making an air-tight joint between the top ring and cover) to be jammed into them, and thus forming a more perfect joint.

The cover is to have small grooves as described for ring.

The leather washer is to be laid on the top ring and the cover placed over it, and secured by three square-headed screws .5 inch in diameter.

The iron cylinder and the screws are to be tinned all over previous to securing the gun metal bottom and top angular ring to it. (The gun metal does not require tinning.)

When finished, the cylinder is to receive a coating of Brunswick black in the interior, and two coats of dark green paint on the exterior.

DESCRIPTION OF GOVERNMENT SAFETY CASE, WITH CIRCULAR ENDS, FOR CONVEYANCE OF GUNPOWDER BY RAILWAY.

FOR "CASE METAL LINED WHOLE."

The material and dimensions of the safety case to be as follows :—

The body of the case to be made of the Best Best Staffordshire Iron, No. 15 B.W.G. Length 21¾ inches, width 17¾ inches, depth 18⅝ inches (internal measurement), the body to be tinned both inside and outside, the joints to be mitred.

All rivets to be of the best wrought copper, pitched about 2½ inches from centre to centre, to be countersunk inside, and flush with the body.

The ends of the case to be circular and made of tough R.C.D. bronze, the outside diameter at rims 29½ inches, 1 3/16 inches wide and 5/8 inch thick at the centre, the webs to be 3/8 inch thick, and to have perforations to increase elasticity and lightness without diminishing strength.

The ends to be riveted to the body with 36 rivets in each, one end to have an opening for the lid equal to the outside dimensions of the body at one end. The lid to be of the same description of material as the ends, and secured to the open end with twelve Delta metal bolts 1 inch by ½ inch with hexagon heads. The joint to be 1 inch wide, and to be smoothly and evenly finished—to have a leather washer in one piece, without a joining, properly fitted so as to form an air-tight joint.

The outside corners of the body to be strengthened by angular pieces 1¼ inch wide by 3/16 inch thick, made of the same description of material as the ends, and riveted to the body and flanges of each end with rivets.

The corners inside the body after riveting to be tinned. The case to be painted with one coat of Brunswick black inside, and two coats of whatever coloured paint is decided upon outside.

DESCRIPTION BY MESSRS CURTISS & HARVEY, OF TWO METALLIC PACKAGES USED BY THEM FOR THE CONVEYANCE OF GUNPOWDER BY RAILWAY BY ORDINARY GOODS TRAIN, REFERRED TO IN REGULATIONS 3 AND 7.

(*Pattern Cylinders of Messrs Curtiss & Harvey's, as described hereunder, are in the custody of the Railway Clearing House.*)

A metallic cylinder of the same shape or form as the present Government Laboratory pattern.

The bottom, top ring or flange, and head, made of gun metal about 3/8 inch thick.

The body of hard rolled brass, No. 18 Birmingham Wire Gauge, and the whole strongly riveted together with copper rivets, and the seams afterwards filled up with solder, making the package air-tight.

A leather washer is placed between the top ring or flange (to which the body is riveted) and the head, and the latter is then fastened by four copper or brass countersunk screws, making a tight joint.

Outside diameter of head is 16 inches.
Inside diameter of cylinder is 14½ inches.
Height of small cylinder is 14½ inches.
Height of long cylinder is 25¾ inches.

The long cylinder has a strengthening ring of gun metal strongly riveted on the outside of body midway between top and bottom.

Description by the New Sedgwick Gunpowder Company of Two Metallic Packages used by them for Conveyance of Gunpowder by Railway, referred to in Regulations 3 and 7.

Quarter or 25 lbs. Cylinder.

The bottom and top covers are made of brass about ¼ inch thick.

The body of Muntz's metal, No. 20 wire gauge, and the whole strongly riveted together with copper rivets, and the seams afterwards filled with solder, making the cylinder air-tight.

A leather washer is placed between the top flange (to which the body is riveted) and the cover, and the latter is then fastened by four brass countersunk screws, making a tight joint.

Outside diameter of head is 12¾ inches.
Inside diameter of cylinder is 10¾ inches.
Height of cylinder is 15 inches.

Whole or 100 lbs. Cylinder.

The bottom and top covers are made of brass about ⅜ inch thick.

The body of Muntz's, No. 18 wire gauge, and the whole strongly riveted together with copper rivets, and the seams afterwards filled up with solder, making the cylinder air-tight.

A leather washer is placed between the top flange (to which the body is riveted) and the cover, and the latter is then fastened by four brass countersunk screws, making a tight joint.

Outside diameter of head about 18½ inches.
Inside diameter of cylinder about 16½ inches.
Height of cylinder about 22½ inches.

The cylinder has a strengthening ring or band of Muntz's metal strongly riveted on the outside of body midway between top and bottom.

APPENDIX.

English Weights and Measures.

AVOIRDUPOIS.

	Grains.	Drachms.	Ounces.	Lbs.	Qrs.	Cwts.	Tons.
Grain	1						
Drachm	27·34	1					
Ounce	437·5	16	1				
Pound	7,000	256	16	1			
Quarter	196,000	7,168	448	28	1		
Cwt.	784,000	28,672	1,792	112	4	1	
Ton	15,680,000	573,440	35,840	2,240	80	20	1

TROY WEIGHT.

	Grains.	Dwts.	Ounces.	Lb.
Grain	1			
Pennyweight	24	1		
Ounce	480	20	1	
Pound	5,760	240	12	1

1 gallon = 277·276 cubic inches.
1 pint = 34·659 ,,
1 fluid ounce = 1.7329 ,,
1 litre = 61.02705 ,,
1 cubic centimetre = 0.06102705 cubic inches.
1 cubic inch = 16.386176 cubic centimetres.

1 cubic inch of distilled water in air at 62° F. = 252.336 grains.
1 cubic inch ,, ,, *in vacuo* at 62° F. = 252.645 grains.

1 minim is the volume of 0.91 grain of water.
1 fluid drachm ,, of 54.68 grains of water.
1 fluid ounce ,, of 437.5 grains of water.
1 gallon is the ,, of 10 pounds or 70,000 grains of water.

Weights and Measures of the British Pharmacopœia of 1867.

WEIGHTS.

1 grain, gr.
1 ounce, oz. = 437.5 grains.
1 pound = 16 ozs. = 7,000 ,,

MEASURES OF CAPACITY.

1 minim, min.
1 fluid drachm, fl. drm. = 60 minims.
1 fluid ounce, fl. oz. = 8 fluid drachms.
1 pint, O = 20 fluid ounces.
1 gallon, C = 8 pints.

MEASURES OF LENGTH.

1 line = $\frac{1}{12}$ inch.
1 inch = $\frac{1}{39.1393}$ seconds—pendulum.
12 inches = 1 foot.
36 ,, = 3 feet = 1 yard.

Weights and Measures of the Metrical System.

WEIGHTS.

1 milligram = .001 grm.
1 centigram = .01 ,,
1 decigram = 0.1 ,,
1 grm. = weight of a cubic centimetre of water at 4° C.
1 decagram = 10 grms.
1 hectogram = 100 ,,
1 kilogram = 1,000 ,,

MEASURES OF CAPACITY.

1 millilitre = 1 cubic centimetre of water at 4° C.
1 centilitre = 10 cubic centimetres.
1 decilitre = 100 ,, ,,
1 litre = 1,000 ,, ,,

MEASURES OF LENGTH.

1 millimetre = .001 metre.
1 centimetre = .01 ,,
1 decimetre = 0.1 ,,
1 metre = the ten millionth part of a quarter of the earth's meridian (nearly).

Tables for Conversion of Metrical and English Measures.

A. LENGTH.

METRICAL TO ENGLISH.		ENGLISH TO METRICAL.	
(1) Millimetres to Inches.	(2) Metres to Feet.	(3) Inches to Millimetres.	(4) Feet to Metres.
1=0.03937079	1= 3.2808992	1= 25.39954	1=0.30479449
2=0.07874158	2= 6.5617984	2= 50.79908	2=0.60958898
3=0.11811237	3= 9.8426976	3= 76.19862	3=0.91438347
4=0.15748316	4=13.1235968	4=101.59816	4=1.21917796
5=0.19685395	5=16.4044960	5=126.99770	5=1.52397245
6=0.23622474	6=19.6853952	6=152.39724	6=1.82876694
7=0.27559553	7=22.9662944	7=177.79678	7=2.13356143
8=0.31496632	8=26.2471936	8=203.19632	8=2.43835592
9=0.35433711	9=29.5280928	9=228.59586	9=2.74315041

B. CAPACITY.

METRICAL TO ENGLISH.

(1) Cubic Centimetres to Cubic Inches.	(2) Litres to Fluid Ounces.	(3) Litres to Pints.	(4) Litres to Gallons.
1=0.06102705	1= 35.215468	1= 1.7607734	1=0.22009668
2=0.12205410	2= 70.430936	2= 3.5215468	2=0.44019336
3=0.18308115	3=105.646404	3= 5.2823202	3=0.66029004
4=0.24410820	4=140.861872	4= 7.0430936	4=0.88038672
5=0.30513525	5=176.077340	5= 8.8038670	5=1.10048340
6=0.36616230	6=211.292808	6=10.5646404	6=1.32058008
7=0.42718935	7=246.508276	7=12.3254138	7=1.54067676
8=0.48821640	8=281.723744	8=14.0861872	8=1.76077344
9=0.54924345	9=316.939212	9=15.8469606	9=1.98087012

ENGLISH TO METRICAL.

(1) Cubic Inches to Cubic Centimetres.	(2) Fluid Ounces to Cubic Centimetres.	(3) Pints to Litres.	(4) Gallons to Litres.
1 = 16.386176	1 = 28.396612	1 = 0.567932	1 = 4.543458
2 = 32.772352	2 = 56.793224	2 = 1.135864	2 = 9.086916
3 = 49.158528	3 = 85.189856	3 = 1.703796	3 = 13.630374
4 = 65.544704	4 = 113.586448	4 = 2.271728	4 = 18.173832
5 = 81.930880	5 = 141.983060	5 = 2.839660	5 = 22.717290
6 = 98.317056	6 = 170.379672	6 = 3.407592	6 = 27.270748
7 = 114.703232	7 = 198.776284	7 = 3.975524	7 = 31.804206
8 = 131.089408	8 = 227.172896	8 = 4.543456	8 = 36.347664
9 = 147.475584	9 = 255.569608	9 = 5.111388	9 = 40.891122

C. WEIGHT.

METRICAL TO ENGLISH.

(1) Grammes to Grains.	(2) Kilogrammes to Ounces.	(3) Kilogrammes to Pounds.
1 = 15.4323488	1 = 35.27394	1 = 2.20462
2 = 30.8646976	2 = 70.54788	2 = 4.40924
3 = 46.2970464	3 = 105.82182	3 = 6.61386
4 = 61.7293952	4 = 141.09576	4 = 8.81848
5 = 77.1617440	5 = 176.36970	5 = 11.02310
6 = 92.5940928	6 = 211.64364	6 = 13.22772
7 = 108.0264416	7 = 246.91758	7 = 15.43234
8 = 123.4587904	8 = 282.19152	8 = 17.63696
9 = 138.8911392	9 = 317.46546	9 = 19.84158

ENGLISH TO METRICAL.

(1) Grains to Grammes.	(2) Ounces to Grammes.	(3) Pounds to Kilogrammes.	(4) Hundredweights to Kilogrammes.
1 = 0.0647989	1 = 28.34954	1 = 0.45359265	1 = 50.8023768
2 = 0.1295978	2 = 56.69908	2 = 0.90718530	2 = 101.6047536
3 = 0.1943967	3 = 85.04862	3 = 1.36077795	3 = 152.4071304
4 = 0.2591956	4 = 113.39816	4 = 1.81437060	4 = 203.2095072
5 = 0.3239945	5 = 141.74770	5 = 2.26796325	5 = 254.0118840
6 = 0.3887934	6 = 170.09724	6 = 2.72155590	6 = 304.8142608
7 = 0.4535923	7 = 198.44678	7 = 3.17514855	7 = 355.6166376
8 = 0.5183912	8 = 226.79632	8 = 3.62874120	8 = 406.4190144
9 = 0.5831901	9 = 255.14586	9 = 4.08233385	9 = 457.2213912

Hydrometer Tables.

DENSITIES CORRESPONDING TO DEGREES OF BAUMÉ'S HYDROMETER FOR LIQUIDS HEAVIER THAN WATER.

° B.	Density.	° B.	Density.	° B.	Density.	° B.	Density.
0	1.000	19	1.152	38	1.357	57	1.652
1	1.007	20	1.161	39	1.370	58	1.671
2	1.014	21	1.171	40	1.383	59	1.691
3	1.022	22	1.180	41	1.397	60	1.711
4	1.029	23	1.190	42	1.410	61	1.732
5	1.036	24	1.199	43	1.424	62	1.753
6	1.044	25	1.210	44	1.438	63	1.774
7	1.052	26	1.221	45	1.453	64	1.796
8	1.060	27	1.231	46	1.468	65	1.819
9	1.067	28	1.242	47	1.483	66	1.846
10	1.075	29	1.253	48	1.498	67	1.872
11	1.083	30	1.264	49	1.514	68	1.897
12	1.091	31	1.275	50	1.530	69	1.921
13	1.100	32	1.286	51	1.546	70	1.946
14	1.108	33	1.297	52	1.563	71	1.974
15	1.116	34	1.309	53	1.580	72	2.000
16	1.125	35	1.320	54	1.597	73	2.031
17	1.134	36	1.332	55	1.615	74	2.059
18	1.143	37	1.345	56	1.634		

DENSITIES CORRESPONDING TO BAUMÉ'S HYDROMETER FOR LIQUIDS LIGHTER THAN WATER. (FRANCŒUR.)

° B.	Density.	° B.	Density.	° B.	Density.	° B.	Density.
10	1.000	23	0.918	36	0.849	49	0.789
11	0.993	24	0.913	37	0.844	50	0.785
12	0.986	25	0.907	38	0.839	51	0.781
13	0.980	26	0.901	39	0.834	52	0.777
14	0.973	27	0.896	40	0.830	53	0.773
15	0.967	28	0.890	41	0.825	54	0.768
16	0.960	29	0.885	42	0.820	55	0.764
17	0.954	30	0.880	43	0.816	56	0.760
18	0.948	31	0.874	44	0.811	57	0.757
19	0.942	32	0.869	45	0.807	58	0.753
20	0.936	33	0.864	46	0.802	59	0.749
21	0.930	34	0.859	47	0.798	60	0.745
22	0.924	35	0.854	48	0.794		

DEGREES ON TWADDLE'S HYDROMETER WITH THE CORRESPONDING DENSITIES.

° Tw.	Density.	° Tw.	Density.	° Tw.	Density.	° Tw.	Density.
1	1.005	8	1.040	15	1.075	22	1.110
2	1.010	9	1.045	16	1.080	23	1.115
3	1.015	10	1.050	17	1.085	24	1.120
4	1.020	11	1.055	18	1.090	25	1.125
5	1.025	12	1.060	19	1.095	26	1.130
6	1.030	13	1.065	20	1.100	27	1.135
7	1.035	14	1.070	21	1.105	28	1.140

Degrees Twaddle are converted into the corresponding specific gravities by multiplying them by 5 and adding 1,000.

Comparison of Thermometers.

CONVERSION OF THERMOMETER DEGREES.

° C. to ° R.—Multiply by 4 and divide by 5.
° C. to ° F.—Multiply by 9, divide by 5, then add 32.
° R. to ° C.—Multiply by 5 and divide by 4.
° R. to ° F.—Multiply by 9, divide by 4, then add 32.
° F. to ° R.—First subtract 32, then multiply by 4, and divide by 9.
° F. to ° C.—First subtract 32, then multiply by 5, and divide by 9.

Symbols and Atomic Weights of the Elements.

Element.	Symbol.	Atomic Weight.	Observer.
Aluminium	Al	27.02	Mallet.
Antimony	Sb	120.00	Schneider, Cooke.
Arsenic	As	75.15	Kessler.
Barium	Ba	136.84	Marignac.
Bismuth	Bi	210.00	Dumas.
Boron	B	11.04	Berzelius.
Bromine	Br	79.76	Stas.
Cadmium	Cd	112.04	Lenssen.
Cæsium	Cs	133.00	Bunsen.
Calcium	Ca	39.90	Erdmann.
Carbon	C	11.97	Dumas, Liebig.
Cerium	Ce	138.24	Rammelsberg.
Chlorine	Cl	35.37	Stas.

Element.	Symbol.	Atomic Weight.	Observer.
Chromium	Cr	52.08	Siewart.
Cobalt	Co	58.74	Russell.
Copper	Cu	63.12	Millon and Commaille.
Didymium	D	142.44	Hermann.
Erbium	E	168.90	Bahr and Bunsen.
Fluorine	F	18.96	Luca, Louyet.
Gallium	Ga	69.80	Lecoq de Boisbaudran.
Glucinum	Gl	9.30	Awdejew, Klatzo.
Gold	Au	196.71	Berzelius.
Hydrogen	H	1.00	Dulong and Berzelius.
Indium	In	113.40	Winkler, Bunsen.
Iodine	I	126.54	Stas.
Iridium	Ir	196.87	Berzelius.
Iron	Fe	56.00	Dumas.
Lanthanum	La	139.33	Hermann.
Lead	Pb	206.40	Stas.
Lithium	Li	7.00	Stas.
Magnesium	Mg	23.94	Dumas.
Manganese	Mn	54.04	Schneider.
Mercury	Hg	200.00	Erdmann.
Molybdenum	Mo	96.00	Dumas, Debray
Nickel	Ni	58.74	Russell.
Niobium	Nb	94.00	Marignac.
Nitrogen	N	14.01	Stas.
Osmium	Os	199.03	Berzelius.
Oxygen	O	15.96	
Palladium	Pd	106.57	Berzelius.
Phosphorus	P	30.96	Schrötter.
Platinum	Pt	194.38	Seubert.
Potassium	K	39.04	Stas.
Rhodium	Rh	104.21	Berzelius.
Rubidium	Rb	85.40	Bunsen, Piccard.
Ruthenium	Ru	104.40	Berzelius.
Selenium	Se	79.46	Dumas.
Silver	Ag	107.67	Stas.
Silicon	Si	28.10	Dumas.
Sodium	Na	22.99	Stas.
Strontium	Sr	87.54	Marignac.
Sulphur	S	31.996	Stas.
Tantalum	Ta	182.300	Marignac.
Tellurium	Te	128.06	V. Hauer.
Thallium	Tl	203.66	Crookes.
Thorium	Th	231.44	Delafontaine.

Element.	Symbol.	Atomic Weight.	Observer.
Tin	Sn	118.10	Dumas.
Titanium	Ti	50.00	Pierre.
Tungsten	W	184.00	Schneider, Roscoe.
Uranium	U	237.60	Ebelman.
Vanadium	V	51.35	Roscoe.
Yttrium	Y	92.55	Bahr and Bunsen.
Zinc	Zn	65.16	Oxel Erdmann.
Zirconium	Zr	89.60	Marignac.

Specific Gravity of Various Solid and Liquid Substances.

WATER = 1.

Cork	.24	Pitch	1.15
Poplar	.38	Coal	1.25
Fir	.55	Ebony	1.33
Willow	.58	Lignum Vitæ	1.33
Lithium (metal)	.59	Rubidium	1.52
Elm	.60	Sand	1.52
Cedar of Lebanon	.61	Calcium	1.57
Pear Tree	.66	Magnesium	1.74
Cherry Tree	.71	Chalk	1.79
Ether	.72	Ivory	1.82
Maple	.75	Sulphuric Acid	1.84
Plum Tree	.78	Light Earth	1.98
Apple Tree	.79	Brick	2.00
Yew	.79	Burford Stone	2.04
Ash	.80	Grind Stone	2.14
Spirit of Wine (strong)	.83	Clay	2.16
Beech	.86	Yorkshire Stone	2.44
Oil of Turpentine	.86	Mill Stone	2.48
Potassium	.86	Portland Stone	2.49
Logwood	.91	Bristol Stone	2.51
Gunpowder shaken	.92	Window Glass	2.52
Oak	.92	Strontium	2.54
Wax	.96	Aluminium	2.56
Sodium	.97	Flint	2.57
Common Water	1.00	Rock Crystal	2.60
Sea Water	1.02	Glass	2.64
Boxwood	1.03	Marble	2.70
Mahogany	1.06	Granite	3.00

Diamond	3.50	Copper	8.95
Loadstone	4.93	Cobalt	8.95
Arsenic	5.96	Bismuth	9.79
Tellurium	6.25	Silver	10.53
Antimony	6.71	Lead	11.36
Chromium	6.81	Ruthenium	11.4
Zinc	7.14	Palladium	11.8
Tin	7.32	Thallium	11.91
Cast Iron	7.42	Rhodium	12.1
Iron	7.84	Mercury	13.59
Steel	7.85	Tungsten	17.6
Cast Brass	8.00	Uranium	18.4
Manganese	8.01	Gold	19.34
Cadmium	8.69	Iridium	21.15
Molybdenum	8.62	Osmium	21.4
Gun Metal	8.78	Platinum	21.53
Nickel	8.82		

Specific Gravity of Gases and Vapours.

AIR = 1.

Arsenic Vapour	10.600	Sulphuretted Hydrogen	1.191
Iodine Vapour	8.716	Phosphuretted Hydrogen	1.185
Mercury Vapour	6.976	Oxygen	1.105
Bromine Vapour	5.540	Nitric Oxide	1.039
Phosphorus Vapour	4.500	Heavy Carburetted Hydrogen	.978
Chlorine Gas	2.470	Nitrogen	.972
Sulphurous Acid Gas	2.247	Carbonic Oxide	.967
Sulphur Vapour	2.230	Water Vapour	.622
Carbonic Acid Gas	1.529	Ammonia Gas	.590
Nitrous Oxide	1.527	Light Carburetted Hydrogen	.557
Hydrochloric Acid	1.261	Hydrogen	.069

Relation between "Real" and "Packing" Specific Gravity of Common Salts.

	Alum.	Soda Crystals	Sulphate of Soda.	Sulphate of Magnesia	Anhydrous Carbonate of Soda	Bicarbonate of Soda.
Real Specific Gravity	1.726	1.42	1.50	1.75	2.47	2.2
Packing Specific Gravity	1.040	0.96	0.87	1.03	1.35	1.3
Factor	1.66	1.48	1.72	1.70	1.83	1.7
Mean factor = 1.68.						

Table Showing the Specific Gravity of Important Salts.

	Specific Gravity.		Specific Gravity.
Alum (Potassium)	1.73	Nitrate of Silver	4.36
,, (Ammonium)	1.63	,, of Barium	3.2
Bichromate of Potassimm	2.60	,, of Potassium	2.12
Borax (cryst.)	1.69	,, of Sodium	2.26
Bromide of Silver	6.35	,, of Strontium	2.8
,, of Potassium	2.42	Oxalate of Silver	5.61
Carbonate of Barium	4.3	,, of Lead	6.38
,, of Lead	6.4	,, of Potassium (acid)	3.06
,, of Potassium	2.27	Phosphate of Calcium	3.18
,, of Sodium (crys.)	1.45	,, of Sodium (crys.)	1.52
Chlorate of Potassium	2.35	,, of Ammonium	1.5
Chloride of Ammonium	1.5	Sulphate of Barium	4.5
,, of Silver	5.5	,, of Calcium (gyp.)	2.33
,, of Barium (crys.)	3.05	,, of Copper (crys.)	2.3
,, of Calcium (fus.)	2.21	,, of Iron	1.97
,, of Calcium (crys.)	1.61	,, of Magnesium	1.75
,, of Mercurosum	7.0	,, of Potassium	2.66
,, of Mercuricum	5.42	,, of Sodium (crys.)	1.5
,, of Potassium	1.95	,, of Zinc (crys.)	2.04
,, of Sodium	2.16	Sulphide of Antimony	4.62
Chromate of Lead	6.1	,, of Silver	6.85
,, of Potassium	2.64	,, of Cupricum	4.16
Ferrocyanide of Potassium	1.83	,, of Stannosum	4.97
Iodide of Silver	5.61	,, of Stannicum	4.6
,, of Lead	6.38	,, of Ferrosum	4.4
,, of Potassium	3.86	,, of Mercury	8.13

Table of the Temperature of Steam and Various Pressures.

Atmosphere Included.		Temperature of Steam. F.	Specific Vol.	No. of Atmospheres.	Atmosphere Excluded.	
Lbs. per Sq. Inch.	Inches of Mercury.				Inches of Mercury.	Lbs. per Sq. Inch.
1	2.0355	102.1	20582	.068	– 27.886	– 13.7
2	4.0701	126.3	10721	.136	– 25.851	– 12.7
3	6.1065	141.6	7322	.204	– 23.815	– 11.7
4	8.142	153.1	5583	.272	– 21.780	– 10.7
5	10.178	162.3	4527	.340	– 19.744	– 9.7
6	12.213	170.2	3813	.408	– 17.709	– 8.7
7	14.249	176.9	3298	.476	– 15.673	– 7.7
8	16.284	182.9	2909	.544	– 13.638	– 6.7
9	18.320	188.3	2604	.612	– 11.602	– 5.7
10	20.355	193.3	2358	.680	– 9.567	– 4.7
11	22.391	197.8	2157	.748	– 7.531	– 3.7
12	24.426	202.0	1986	.816	– 5.496	– 2.7
13	26.462	205.9	1842	.884	– 3.460	– 1.7
14	28.497	209.6	1720	.952	– 1.425	– 0.7
14.706	29.922	212.0	1642	1.000	∓ 0.000	∓ 0.0
15	30.533	213.1	1610	1.020	0.611	0.3
16	32.568	216.3	1515	1.088	2.646	1.3
17	34.604	219.6	1431	1.156	4.682	2.3
18	36.639	222.4	1357	1.224	6.717	3.3
19	38.675	225.3	1290	1.292	8.753	4.3
20	40.710	228.0	1229	1.360	10.788	5.3
21	42.746	230.6	1174	1.428	12.842	6.3
22	44.781	233.1	1123	1.496	14.859	7.3
23	46.817	235.5	1075	1.564	16.895	8.3
24	48.852	237.8	1036	1.632	18.930	9.3
25	50.888	240.1	996	1.700	20.966	10.3
30	61.065	250.4	838	2.040	31.143	15.3
35	71.243	259.3	726	2.380	41.321	20.3
40	81.420	267.3	640	2.720	51.498	25.3
45	91.598	274.4	572	3.060	61.676	30.3
50	101.776	281.0	518	3.400	71.854	35.3
55	111.953	287.1	474	3.740	82.031	40.3
60	122.131	292.7	437	4.080	92.209	45.3
65	132.308	298.0	405	4.420	102.386	50.3
70	142.486	302.9	378	4.760	112.563	55.3
75	152.663	307.5	353	5.100	122.741	60.3
80	162.841	312.0	333	5.440	132.919	65.3
85	173.018	316.1	314	5.780	143.096	70.3
90	183.196	320.2	298	6.120	153.274	75.3
95	193.373	324.1	283	6.460	163.451	80.3
100	203.551	327.9	270	6.800	173.629	85.3
110	223.906	334.6	247	7.480	193.984	95.3
120	244.261	341.1	227	8.160	214.339	105.3

TABLE OF THE TEMPERATURE OF STEAM AND VARIOUS PRESSURES—*Continued.*

Atmosphere Included.		Temperature of Steam. F.	Specific Vol.	No. of Atmospheres.	Atmosphere Excluded.	
Lbs. per Sq. Inch.	Inches of Mercury.				Inches of Mercury.	Lbs. per Sq. Inch.
130	264.616	347.2	211	8.840	234.694	115.3
140	284.971	352.9	197	9.520	255.049	125.3
150	305.327	358.3	184	10.200	275.405	135.3
160	325.682	363.4	174	10.880	295.760	145.3
170	346.037	368.2	164	11.560	316.115	155.3
180	366.392	372.9	155	12.240	336.470	165.3
190	386.747	377.5	148	12.920	356.825	175.3
200	407.102	381.7	141	13.600	377.180	185.3
250	508.878	401.1	114	17.000	478.956	235.3
300	610.653	417.5	96	20.400	580.731	285.3
350	712.429	430.1	83	23.800	682.507	335.3
400	814.204	444.9	73	27.200	784.282	385.3
450	915.980	456.7	66	30.600	886.058	435.3
500	1017.755	467.5	59	34.000	987.833	485.3
600	1221.306	487.0	50	40.800	1191.384	585.3
700	1424.857	504.1	43	47.600	1394.935	685.3
800	1628.408	519.5	38	54.400	1598.486	785.3
900	1831.959	533.6	34	61.200	1802.037	885.3
1000	2035.510	546.5	31	68.000	2005.588	985.3

Walker's List of Frigorific Mixtures.

		Thermometer Sinks Degrees F.
Ammonium Nitrate	1 part	From +40° to +4°
Water	1 ,,	
Ammonium Chloride	5 ,,	From +50° to +10°
Potassium Nitrate	5 ,,	
Water	16 ,,	
Ammonium Chloride	5 ,,	From +50° to +4°
Potassium Nitrate	5 ,,	
Sodium Sulphate	8 ,,	
Water	16 ,,	
Sodium Nitrate	3 ,,	From +50° to -3°
Nitric Acid, diluted	2 ,,	
Ammonium Nitrate	1 ,,	From +50° to -7
Sodium Carbonate	1 ,,	
Water	1 ,,	

		Thermometer Sinks Degrees F.
Sodium Phosphate	9 parts	From +50° to −12°
Nitric Acid, diluted	4 ,,	
Sodium Sulphate	5 ,,	From +40° to +3°
Sulphuric Acid, diluted	4 ,,	
Sodium Sulphate	6 ,,	From +50° to −10°
Ammonium Chloride	4 ,,	
Potassium Nitrate	2 ,,	
Nitric Acid, diluted	4 ,,	
Sodium Sulphate	6 ,,	From +50° to −40°
Ammonium Nitrate	5 ,,	
Nitric Acid, diluted	4 ,,	
Snow, or Pounded Ice	2 ,,	to −5°
Sodium Chloride	1 ,,	
Snow, or Pounded Ice	5 ,,	to −12°
Sodium Chloride	2 ,,	
Ammonium Chloride	1 ,,	
Snow, or Pounded Ice	24 ,,	to −18°
Sodium Chloride	10 ,,	
Ammonium Chloride	5 ,,	
Potassium Nitrate	5 ,,	
Snow, or Pounded Ice	12 ,,	to −25°
Sodium Chloride	5 ,,	
Ammonium Nitrate	5 ,,	
Snow	3 ,,	From +32° to −23°
Sulphuric Acid, diluted	2 ,,	
Snow	8 ,,	From +32° to −27°
Hydrochloric Acid	5 ,,	
Snow	7 ,,	From +32° to −30°
Nitric Acid, diluted	4 ,,	
Snow	4 ,,	From +32° to −40°
Calcium Chloride	5 ,,	
Snow	2 ,,	From +32° to −50°
Calcium Chloride, crystallised	3 ,,	
Snow	3 ,,	From +32° to −51°
Potash	4 ,,	

INSURANCE.

Insurance of Goods named in the Carriers' Act.

The following classification, scales of charges, and conditions apply whether the articles be conveyed by goods or passenger trains; but parcels up to and including 28 lbs. in weight are to be insured only when sent by passenger train.

CLASSIFICATION.

CLASS I.

1. Stamps.
2. Maps.
3. Silks, or Goods mixed with Silk where Silk is more than 30 per cent. of the value.
4. Furs.
5. Clocks.
6. Timepieces.
7. Plated Articles.
8. Coins, Gold and Silver.
9. Gold and Silver, manufactured and unmanufactured.
10. Jewellery. (See Note *a.*)
11. Watches.
12. Gold and Silver Plate.
13. Hand-made Lace.
14. Engravings.
15. Trinkets.
16. Bank Notes.
17. Title Deeds.
18. Writings.
19. Bills of Exchange.
20. Orders, Notes, or Securities for payment of money, English or Foreign.

CLASS II.

1. Glass of all kinds, except as named in Class IV.
2. China from Manufacturers or Factors.
3. Precious Stones, *set or unset.*
4. Jewellery, *not* from or to Manufacturers or Factors.

CLASS III.

1. Pictures and Paintings.

CLASS IV.

1. Plate Glass (in plates exceeding 36 feet superficial in size each).
2. Glass (stained).
3. Glass (silvered).
4. Glass (bent).
5. China (other than from Manufacturers or Factors).

N.B.—In mixed silk goods where there is less than 30 per cent. of silk, the exemption of the Carriers' Act is not to be pleaded at all, but all such goods are to be carried at the carrier's risk.

For Scale of Charges, *see* next page.

MEMO.—Articles (as above) named in the Carriers' Act, but not classified in the General Classification of Goods, must be carried only by special arrangement.

NOTE.—(*a*) Jewellery when containing Precious Stones from or to Manufacturers or Factors will be charged at the rates for articles in Class II.

Scale of Charges for Insurance.

MAXIMUM CHARGE.	Between all Stations in Great Britain, including the Isle of Wight.								Between all Stations in Ireland.								Between Stations in Great Britain and (*a*) Ports in Ireland, when the carriage between the British and Irish Ports is wholly by sea. (*b*) The British Isles.								Between Stations in Great Britain and (*a*) Ports in Ireland, when the carriage between the British and Irish Ports is partly by sea and partly by land. (*b*) Interior Stations in Ireland.							
	Class1		Class2		Class3		Class4		Class1		Class2		Class3		Class4		Class1		Class2		Class3		Class4		Class1		Class2		Class3		Class4	
	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.
For £25 or less in value .	0	3	0	6	1	3	2	6	0	6	1	0	2	6	5	0	0	9	1	6	3	9	7	6	1	0	2	0	5	0	10	0
26 to £50 ,, .	0	6	1	0	2	6	5	0	1	0	2	0	5	0	10	0	1	6	3	0	7	6	15	0	2	0	4	0	10	0	20	0
51 ,, 75 ,, .	0	9	1	6	3	9	7	6	1	6	3	0	7	6	15	0	2	3	4	6	11	3	22	6	3	0	6	0	15	0	30	0
76 ,, 100 ,, .	1	0	2	0	5	0	10	0	2	0	4	0	10	0	20	0	3	0	6	0	15	0	30	0	4	0	8	0	20	0	40	0
101 ,, 125 ,, .	1	3	2	6	6	3	12	6	2	6	5	0	12	6	25	0	3	9	7	6	18	9	37	6	5	0	10	0	25	0	50	0
126 ,, 150 ,, .	1	6	3	0	7	6	15	0	3	0	6	0	15	0	30	0	4	6	9	0	22	6	45	0	6	0	12	0	30	0	60	0
151 ,, 175 ,, .	1	9	3	6	8	9	17	6	3	6	7	0	17	6	35	0	5	3	10	6	26	3	52	6	7	0	14	0	35	0	70	0
176 ,, 200 ,, .	2	0	4	0	10	0	20	0	4	0	8	0	20	0	40	0	6	0	12	0	30	0	60	0	8	0	16	0	40	0	80	0
201 ,, 225 ,, .	2	3	4	6	11	3	22	6	4	6	9	0	22	6	45	0	6	9	13	6	33	9	67	6	9	0	18	0	45	0	90	0
226 ,, 250 ,, .	2	6	5	0	12	6	25	0	5	0	10	0	25	0	50	0	7	6	15	0	37	6	75	0	10	0	20	0	50	0	100	0
251 ,, 275 ,, .	2	9	5	6	13	9	27	6	5	6	11	0	27	6	55	0	8	3	16	6	41	3	82	6	11	0	22	0	55	0	110	0
276 ,, 300 ,, .	3	0	6	0	15	0	30	0	6	0	12	0	30	0	60	0	9	0	18	0	45	0	90	0	12	0	24	0	60	0	120	0
301 ,, 325 ,, .	3	3	6	6	16	3	32	6	6	6	13	0	32	6	65	0	9	9	19	6	48	9	97	6	13	0	26	0	65	0	130	0
326 ,, 350 ,, .	3	6	7	0	17	6	35	0	7	0	14	0	35	0	70	0	10	6	21	0	52	6	105	0	14	0	28	0	70	0	140	0
351 ,, 375 ,, .	3	9	7	6	18	9	37	6	7	6	15	0	37	6	75	0	11	3	22	6	56	3	112	6	15	0	30	0	75	0	150	0
376 ,, 400 ,, .	4	0	8	0	20	0	40	0	8	0	16	0	40	0	80	0	12	0	24	0	60	0	120	0	16	0	32	0	80	0	160	0
401 ,, 425 ,, .	4	3	8	6	21	3	42	6	8	6	17	0	42	6	85	0	12	9	25	6	63	9	127	6	17	0	34	0	85	0	170	0
426 ,, 450 ,, .	4	6	9	0	22	6	45	0	9	0	18	0	45	0	90	0	13	6	27	0	67	6	135	0	18	0	36	0	90	0	180	0
451 ,, 475 ,, .	4	9	9	6	23	9	47	6	9	6	19	0	47	6	95	0	14	3	28	6	71	3	142	6	19	0	38	0	95	0	190	0
476 ,, 500 ,, .	5	0	10	0	25	0	50	0	10	0	20	0	50	0	100	0	15	0	30	0	75	0	150	0	20	0	40	0	100	0	200	0

The above charges apply irrespective of distance.

Conditions of Insurance.

1. The Insuring Company reserves the right of inspecting, before effecting any insurance, all goods delivered to them for insurance, to ascertain that the articles are in accordance with the Declaration, and are in good condition and well packed.

2. The Insurance is to apply only to the point to which the carriage charges cover conveyance and delivery of the insured articles.

3. The Insurance charges upon insured goods and parcels should always be accepted at the original forwarding station, as covering the entire throughout distance from such forwarding station to the station nearest the ultimate destination of the goods or parcels, whether the invoicing or booking be throughout or otherwise; and no alteration is to be made in the existing invoicing and booking arrangements of the Companies, so far as regards the ordinary Railway charges.

4. When Insurance is effected, Owner's Risk Rates are to be charged, where such are in existence.

5. The contract for Insurance must be made by the Forwarding Company, and with the sender only, and the charge for Insurance must be prepaid.

6. The Insurance of articles exceeding £500 in value, and so declared, to be subject to special arrangements with the Goods Manager or Superintendent, as the case may be.

7. In the event of a consignment tendered for Insurance consisting of more packages than one, *the value of each package must be declared separately*, but the charge for Insurance must be upon the aggregate value of the whole number of packages.

8. Upon goods returned unsold from exhibitions at half rates, the full charge for Insurance must in all cases be made up to £500 declared value; above that amount, by special arrangement, *vide* Clause 6.

9. The Company at the Station of destination reserves the right of sending a representative to be present at the unpacking of Insured articles.

The following Lines of Steamers *adopt* the foregoing general arrangement for the Insurance of goods and parcels, viz. :—

Barrow Steam Navigation Company.
City of Cork Steam Packet.
City of Dublin Steam Packet.
Larne and Stranraer Steamboat.
A. A. Laird & Company.

Also the Dublin and Glasgow Steam Packet, *for traffic exchanged with the Caledonian, Glasgow and South-Western, or North British Companies via Glasgow, but not for any other traffic.*

The following *do not adopt* the general arrangement, viz. :—

Ayr Steam Shipping.
Belfast Steamship Limited.
Burns, G. & J.
Carron Company.
Clyde Shipping Company.
Dublin and Liverpool Screw Steam Packet.
Dublin, Silloth, and Isle of Man Steamers (William Sloan & Co.).
Dundalk and Newry Steam Packet.
M. Langlands & Sons.
Waterford Steamship.

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